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EDITORIAL NOTES.

THE Council of the Geological Society has announced the distribution of the Medals and Awards for this year as follows:—Wollaston Medal, Mr. G. W. Lamplugh; Murchison Medal, Dr. H. H. Thomas; Lyell Medal, Mr. J. F. N. Green; Bigsby Medal, Mr. C. W. Knight; Wollaston Fund, Dr. A. Brammall; Murchison Fund, Dr. A. E. Trueman; Lyell Fund, Dr. J. A. Thomson and Dr. W. A. Richardson.

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THE Sedgwick Prize, which is given triennially by the University of Cambridge for an essay on some geological subject previously announced, is awarded for 1925 to Mr. Hugh Hamshaw Thomas, Fellow of Downing College. The subject for the year 1928 is "Contributions to the Geology of some district in which Sedgwick worked". The prize is open to all graduates of the University who shall have resided sixty days during the twelve months preceding the day on or before which the Essays must be sent in, in this case 1st October, 1927.

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AT the Annual General Meeting of the Geologists' Association in February, 1925, the Foulerton Award will be presented to Mr. A. L. Leach, F.G.S., who has contributed several papers to the *Proceedings*, has conducted numerous excursions, and from 1913 to 1918 was Honorary Secretary of the Association; for nearly four years, during the war, he was also Excursions Secretary. As from 31st December, 1924, Mr. W. Wright has resigned the office of Honorary Secretary, and his successor will shortly be appointed.

ORIGINAL ARTICLES.

Notes on the Structure of an Early *Dictyonema*.

By O. M. B. Bulman, Beit Scientific Research Fellow of the Imperial College of Science and Technology.

IT is now nearly thirty years ago that a number of papers were published by Wiman on the minute structure of certain graptolites. To obtain satisfactory results by the methods he describes, well-preserved and uncrushed material is essential, and it is doubtless due to the rarity of suitable material that, since then, comparatively little work in this direction appears to have been done. The following notes are descriptive of results obtained by an application of his methods to some well-preserved *Dictyonema* material from the Shineton[1] Shales.

I. Horizon and Source of the Material.

The material described in the present paper was obtained from what appears to be the highest part of the *Dictyonema flabelliforme* zone—immediately underlying beds rich in *Clonograptus* and *Bryograptus*—of the Shineton Shales of the Dingles, near Leighton, south of the Wrekin. At this high level in the zone *Dictyonema* occurs associated with *Clonograptus*, numerous brachiopods (including *Lingulella nicholsoni*), some trilobites (which are being specifically determined by my colleague), and other forms.

The state of preservation is remarkably good, so that in many specimens not only are the stipes and thecae preserved in considerable relief, but the entire colony, far from being flattened, is distinctly lenticular in cross-section, leaving no doubt as to its original conical shape. The cones generally attain an axial length of about 5 cm., but a few of the specimens collected would appear to have exceeded this, and to have reached a length of 7 cm. Most of the material, however, is more or less fragmentary, and from this locality (*a* 26) only one specimen has been obtained which shows the sicula. Except as a result of recent weathering, the specimens in all cases possess a well-preserved periderm, and they are filled with pyrites.

The material is identical with what is usually referred to *D. flabelliforme* Eich., but it is not unequivocally *D. flabelliforme* forma typica. Until this and the forms from neighbouring localities are worked out in greater detail, and with special reference to the varieties recognized by the Scandinavian workers, it can only be referred to *D. flabelliforme* in the broad sense. The following brief description may be sufficient to define the type :—

Stipes long, straight, sub-parallel ; branching at infrequent intervals ; width of stipes 0·5 mm., separated by 1·0–1·3 mm.

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[1] Although the word "Sheinton"—thus spelt—is recognized locally and on the 6 in. Ordnance Survey Maps and appears to hold priority, the customary spelling in previous geological literature has been retained throughout this paper.

(slight compression increases the former and decreases the latter measurement, so that the figures are not altogether constant: they represent, however, the average).

Hydrothecae number 14–15 in 10 mm. distally, but proximally may be as few as 11–12 in 10 mm. Hydrothecal aperture with a stout rounded or obtusely-pointed spine. Spiral arrangement of the thecae (characteristic of later species) barely suggested by the undulating line of the thecae along the stipe.

Dissepiments very fine, usually given off at right angles from the level of every second theca, so that the mesh is characteristically rectangular, with the dimensions 1–1·3 mm. (wide) × 1·4 mm. (long).

Sicula 1·4 mm. long, with well-developed virgella.

II. METHOD OF ISOLATION.

Following the work of Gümbel (1)[1] and Holm (2), who isolated certain graptolites by dissolving them out of a calcareous matrix with dilute acids, Wiman (3 and 4) succeeded in isolating specimens (including *Dictyonema rarum*) not only from calcareous rocks, but also from shales and cherts. A full description of his technique is given in the two papers cited. A similar method has recently been described by Walton (5) in his paper "On a new method of investigating fossil plant impressions and incrustations".

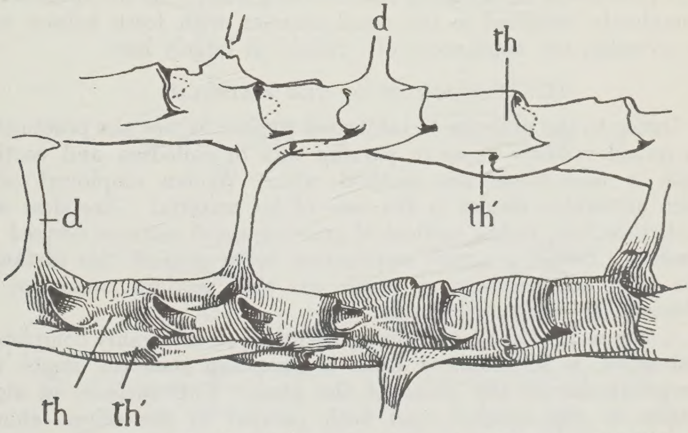

FIG. 1.—Inner (thecal) side of the two stipes of *Dictyonema flabelliforme*, isolated with HF; th, th′ = the two types of thecae, d = dissepiments. Apertural spines of the hydrothecae (largely broken away in this specimen) are represented by dotted lines (× 18). (N.B.—The method of shading adopted in Figs. 1 and 11 is purely conventional, and does not indicate the presence of growth lines or superficial ornamentation.)

The Shineton Shales split readily along the bedding planes, and in nearly every case reveal the outer (convex) side of a *Dictyonema* colony (where such is present)—that is to say, the shale tends to split round rather than through the colony. This outer surface is cemented by Canada balsam to a glass slip, and the shale ground away from the other surface, care being taken that the grinding is not carried so far as to expose any of the graptolite. The purpose of the grinding is simply to leave as little shale as possible, and so to accelerate the process of solution.

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[1] Figures in parentheses refer to Bibliography at end of paper.

Hydrofluoric acid (HF) is then applied to the ground surface, either by pouring on a few drops, or by coating the entire slide (with the exception of the shale) with wax, and immersing it bodily in the acid. Solution is soon impeded in the case of a highly aluminous shale, by the formation of a white gelatinous layer—probably aluminium fluoride. This may be removed, after washing the slide, with a fine camel-hair brush, but seldom without injury to the specimen, especially in the later stages of the process; and it has been found best to dissolve away this layer with strong H_2SO_4—despite the action of the latter upon the balsam.

On the complete removal of the shale, the graptolite which is left adhering to the balsam is allowed to dry and is then washed over with xylol, which forms a thin layer of dissolved balsam all over it and prevents it from flaking and breaking away. If the specimen is completely mounted in the usual manner with fresh balsam and a coverslip, the appearance of "relief" is largely lost.

III. SECTIONING OF THE MATERIAL.

Owing to the presence of infiltrated pyrites, it was not practicable to imbed isolated stipes in paraffin wax or collodion and section with a microtome—the method which Wiman employed with such admirable results in the case of his material. Recourse was had, therefore, to the method of grinding serial sections devised by Professor Sollas, a simple application being used in this instance, the chief disadvantage of which was that sections could not be obtained at uniform intervals.

A fragment of shale containing *Dictyonema*, preferably completely imbedded, is so mounted upon a glass slip that the stipes are perpendicular to the plane of the glass. Two surfaces at right angles to one another, and both parallel to the stipes, should previously be ground upon the shale. These surfaces subsequently form "datum lines", constituting fixed lines throughout the series of sections: that is to say, these two surfaces, being perpendicular to the glass, do not shift their position laterally in any of the sections. If a fragment of shale is used on which *Dictyonema* is superficial, this surface may often be regarded as sufficiently plane, over short distances, to be used as one of the datum lines. In the case of a shale, such as the Shineton Shale, which breaks up in water, it is necessary to boil the fragment in balsam dissolved in xylol before cementing it to the glass slip.

The shale is then ground away parallel to the glass on a Water-of-Ayr stone, and at intervals the grinding is stopped, a coverslip affixed with glycerine, and the surface photographed. Each photograph should include both the datum lines mentioned above, so that reconstructions—such as front elevation and longitudinal sections—may be obtained. The thickness ground away between each section may be conveniently measured with a spherometer.

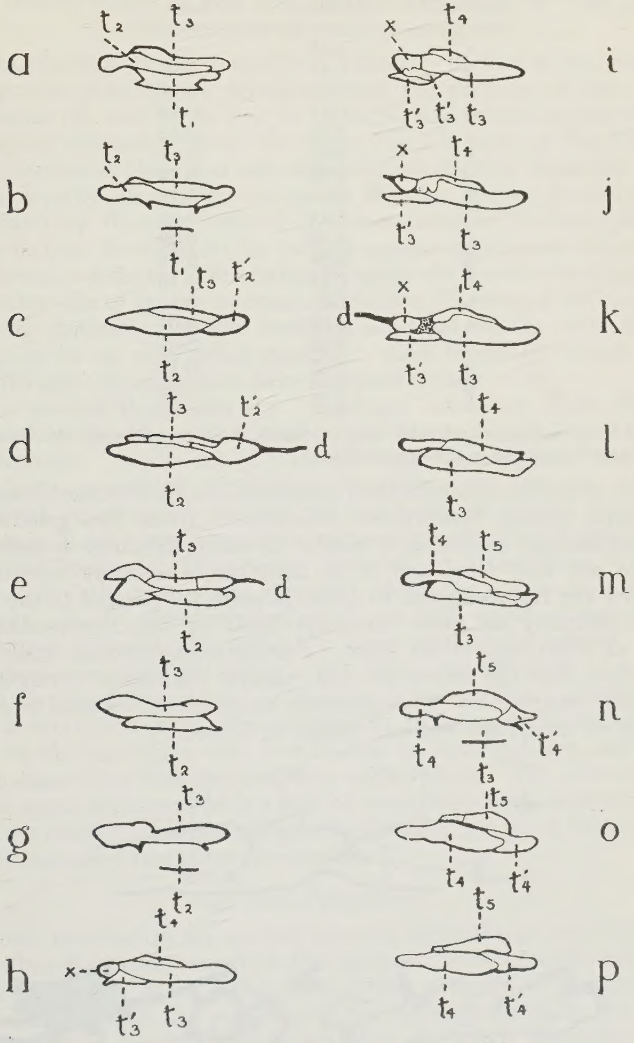

FIG. 2.—Serial sections of a stipe of *Dictyonema flabelliforme*. t_1, $_2$, etc. = hydrothecae, t'_2, $_3$, etc. = "bithecae," x = "special chamber," see section IV*c*, d = dissepiment. (× 30.)

The readings for the sections represented in Fig. 2 and for the reconstructions from them were as follows :—

Section.	Spherometer reading.	Thickness in mm.
a	6·56	—
b	6·46	0·10
c	6·30	0·16
d	6·11	0·19
e	5·95	0·16
f	5·81	0·14
g	5·68	0·13
h	5·54	0·14
i	5·48	0·06
j	5·39	0·09
k	5·28	0·11
l	5·18	0·10
m	5·08	0·10
n	5·01	0·07
o	4·93	0·08
p	4·83	0·10
q	4·75	0·08
r	4·67	0·08

(N.B.—Sections q and r are only represented in Fig. 6 in reconstructions of two other stipes cut in the same series.)

The grinding of longitudinal serial sections by this simple method presents almost insuperable difficulties. Even the grinding of a longitudinal section is a matter of some difficulty because the stipes are very thin, and it is, therefore, absolutely essential to mount the fragment and to grind it perfectly parallel to the glass. Any obliquity at once manifests itself by the disappearance of one or other end of the stipe. Further complications ensue from the fact that the stipes are not always absolutely straight. It is more satisfactory to reconstruct longitudinal sections from the series of transverse sections (Figs. 4, 5, and 6).

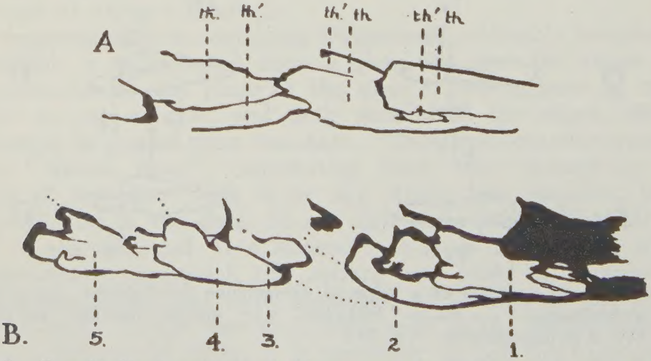

Fig. 3.—Longitudinal sections of *Dictyonema flabelliforme*. A, th = hydrothecae, th' = bithecae (compare with Fig. 7). B (laterally compressed stipe) 1, 2, 3, etc. = hydrothecae (compare with Fig. 4). (× 18.)

Fig. 3, however, is reproduced from photographs obtained of longitudinal sections.

IV. DESCRIPTION OF THE STRUCTURES REVEALED BY THE ABOVE METHOD IN *D. FLABELLIFORME.*

Examination of the inner (or " thecal ") surface of an isolated *Dictyonema flabelliforme* reveals at once the presence of two types of thecae (th and th′ in Fig. 1)—a larger and a smaller, the latter springing alternately from the right and left sides of the former. The presence of these was first definitely recorded by Holm (op. cit.; see especially plate i, fig. 4) in the Silurian species *D. cervicorne* and later by Wiman (1895) in *D. rarum* (another Silurian species). Prior to this, the views on the subject appear to have been somewhat vague and indefinite. Thus Salter (6) spoke of a double row of cells on the inner side of the hydrosome: Nicholson (7) referred to " cellules forming distinctly angular denticles arranged on the sides of the branches in an alternating manner ", while Dames (8) denied this, and Brögger (9) appears to have accepted Dames' view.

The smaller thecae are the " bithecae " of Holm, while Wiman referred to the larger and smaller as " thecae " and " gonangia " respectively. As the use of Wiman's term " gonangium " involves a definite expression of opinion concerning the function of the zooid which occupied the cell, it has been considered advisable to retain Holm's not altogether unexceptionable term " bitheca ".[1]

In the species of *Dictyonema* described by Holm from Silurian rocks, the cell groups are arranged along the stipes in a spiral manner. In *D. flabelliforme* there is no such spiral arrangement, the thecae opening always to the inner side of the colony; but the thecae are arranged along a line which has the form of a very much flattened sine-curve. The lower stipe of Fig. 1 shows $\frac{1}{4}$ of such a curve (the seven thecae gradually swinging from the bottom edge to the top edge), and it will thus be seen that in a complete curve something like thirty thecae are involved. The absence of a true spiral arrangement is a fact of some importance in connexion with the relation of *D. flabelliforme* to the later species of *Dictyonema* and is discussed further under Section V.

(*a*) *The Hydrothecae.*

In the material so far worked out, the hydrothecae are typically somewhat flattened, except at the aperture, which usually exhibits quite prominent relief. This is doubtless a result of compression of thecae of which the periderm of the lip, and especially the sides of the lip, is sensibly thickened and therefore strengthened.[2]

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[1] " Bithecae " being used to denote the smaller thecae, " Hydrothecae " is used for the larger, the term " thecae " being here employed collectively, for the two.

[2] Thickening of the periderm at various points, including the aperture, was noted in the Graptoloidea by Gümbel (op. cit., pp. 293–4, fig. 1).

The aperture itself is possessed of a short spine, which is seen to be pointed in laterally compressed stipes (e.g. Fig. 3B), though very commonly it is rounded. In isolated specimens the apertural spine is often broken away, but its presence is admirably demonstrated in certain of the serial sections (Fig. 2, sections b, g, and n), and it is represented in reconstructions from these sections.

The reconstructed longitudinal section (Fig. 4) may be given two interpretations : (i) that there is a rather ill-defined " common canal " and the hydrothecae do not overlap one another perceptibly, or (ii) that the hydrothecae overlap for a distance of one-half their total length, and there is no " common canal ". The additional evidence afforded by further reconstructions appears to justify the contention that the latter interpretation is correct, for the following reasons : Figures 4 and 5 show, by shading, the internal boundaries and extent of one complete hydrothecal cavity, and its disposition with reference to the external portions of several other thecae. The initial portion and the indisputably thecal portion together constitute a definite structural unit, the shape of which is readily explicable on commonly accepted views on growth and development. If, on the other hand, this initial portion be regarded as part of a " common canal ", then (*a*) the hydrothecae would be perfectly

FIG. 4.

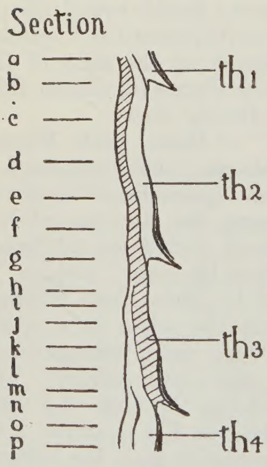

FIG. 5.

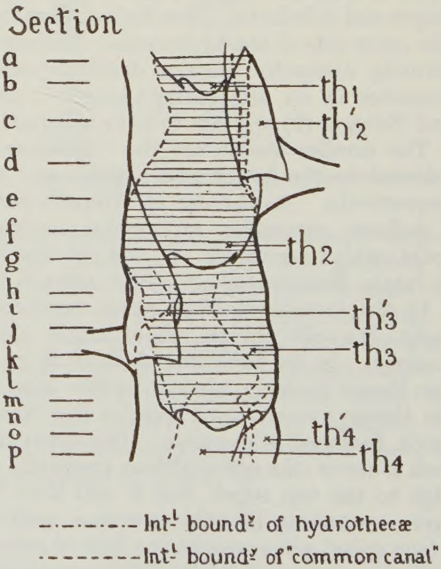

FIG. 4.—Reconstructed longitudinal section (× 30).
FIG. 5.—Reconstructed front elevation (× 30).
th$_1$, $_2$, etc. = hydrothecae. th'$_2$, $_3$, etc. = bithecae. Both figures obtained from the series of sections represented in Fig. 2. The shaded areas of the two diagrams correspond, and indicate one complete hydrothecal cavity.

continuous with the "common canal" so that no definite dividing line could be drawn: (*b*) the "common canal" itself would have the form of a periodically and peculiarly constricted tube—which peculiarity will be noticed by reference to the area between sections g and h in Fig. 5.

In the absence of a "common canal", *D. flabelliforme* differs from *D. rarum* and shows affinities with the Graptoloidea[1]—affinities rendered more marked by the almost complete absence of any spiral arrangement of the thecae. As in the Graptoloidea, each hydrotheca is produced by budding from the immediately preceding one—a process probably analogous to, say, the lateral budding of *Hydra.*

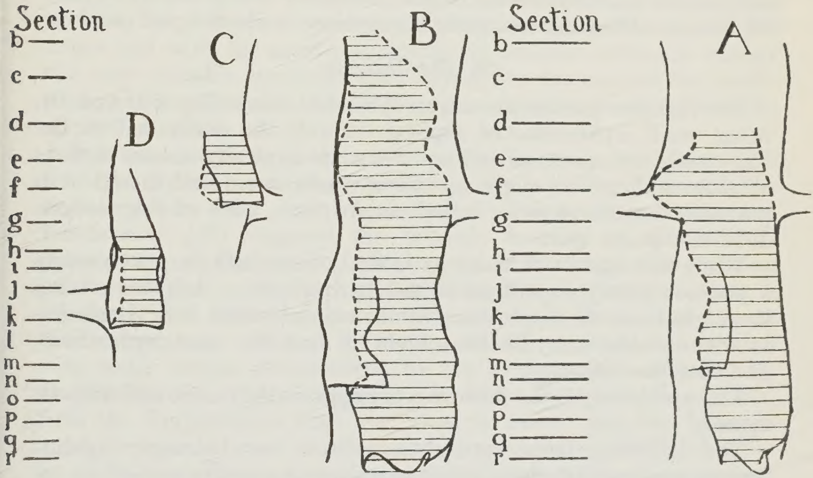

Fig. 6.—A and B, Reconstructions of hydrothecae. C and D, Reconstructions of bithecae (× 30).

Fig. 6 A and B represent the form of the entire cavity of two other hydrothecae, and from these diagrams the overlapping thecae have been omitted. Together with Fig. 5, they may be taken as typifying the general form of the hydrothecal cavity. It is initially (proximally) constricted, and this is a condition that would be expected if it is regarded as produced by a bud from the preceding hydrotheca. It then widens out rapidly—reflecting, no doubt, the growth of the individual—until at or near its mid-length it is almost or quite equal to the whole width of the stipe. About this stage it, in turn, gives rise to a hydrothecal bud,

after which it narrows somewhat to a parallel-sided tube, this portion corresponding to the exposed part of the theca. The actual aperture is always constricted, usually to a very marked degree.

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[1] Dr. Elles, in "The Graptolite Faunas of the British Isles" (*Proc. Geol. Assoc.*, 1922, p. 171), remarks: "There is, in point of fact, no structure at all resembling a common canal from which the thecae bed off, as in the Calyptolastea; the thecae bud directly from each other, the budding orifices remaining permanently open."

The length of any hydrothecal cavity thus defined averages 1·5 mm., the length of the exposed portion thus being of the order of 0·7 mm. It may be that a hydrotheca is budded off from the preceding one at a slightly earlier stage than usual—a feature which might easily be related to the vigour or otherwise of the parent zooid—and in such a case the cell will be rather longer than usual. This also accounts for the fact that some sections through the extreme apertural portion of a hydrotheca demonstrate the presence, simultaneously, of three hydrothecal chambers (Fig. 2, sections a, b, m, and n), while others (Fig. 2, sections f and g) show two only. The two conditions occur among the sections in about equal numbers.

(*b*) *The Bithecae.*

The bithecae possess an extremely simple form (Fig. 6 C and D), being small, cylindrical or slightly conical, the wider end of the cone being the apertural end and they are typically unconstricted ; sometimes there is a slight apertural constriction, and though it is probable that there is an initial constriction, none of the sections definitely prove this.

While one speaks of them as lateral, these bithecae yet occupy a position partly superficial to the hydrothecae. A bitheca takes its origin from the hydrotheca at the side of which it is situated—in other words, a hydrotheca buds off first the next hydrotheca, and then the bitheca.

The apertures of the bithecae are apparently simple and without spines.

The following facts appear to militate very strongly against any suggestion that these bithecae represent gonothecae :—

(i) No structures in any way comparable to them have been recognized in the Graptoloidea. The " corbulae " or " ovarian capsules " of *Diplograptus whitfieldi* (described by Hall) and *D. pristis* (described by Hopkinson) cannot be regarded as definitely analogous. In view of this fact the bithecae are best considered as having lodged some kind of zooid not absolutely essential to the life of the race.

(ii) They are present to the same number as the hydrothecae, occurring in the mature portion of the colony to the extent of 14–15 per cm. along each stipe. It is almost inconceivable that zooids wholly subordinated to a reproductive function should have occurred in such abundance.

(iii) The average dimensions of the bithecae are from one-half or less the width, and from one-third to one-fifth the length, of the hydrothecae. It is not advisable to argue from any supposed relationship exhibited by the Graptolithina to the Coelenterata, but the fact that in the Calyptoblastea the gonothecae are very much larger than the hydrothecae and possess markedly constricted apertures, is not wholly without significance.

(iv) The bithecae are noticed at a very early stage in development (Fig. 11, th^{1}1^{3}; Fig. 12, th′1, th^{1}1^{2}). It is unlikely that an organism should be capable of producing special reproductive individuals at such an immature stage.

It is here suggested that the bithecae lodged individuals something of the nature of the dactylozooids of the Siphonophora and of the Podocorynidae among Gymnoblastea. Frech (10) considered that they might be nematocalyces, and Wiman (11), in opposing this, pointed out that protective zooids (" Wehrpolypen ") usually occur in exposed positions, while the gonangia he regarded as occupying protected positions. It is obvious that in this species at least, the bithecae, occurring as they do along the sides of the stipes and with the apertures commonly directed outwards, occupy the only possible position commanding the lacunae of the meshwork, and are thus able to fulfil their dual function, as dactylozooids, of protecting the colony, and securing food for it.

It is interesting to note here a suggestion made by Allman (12) that the hydrothecae of graptolites may possibly represent the nematophores, the true hydrothecae being suppressed, and Ruedemann (13) suggests the possible bearing on this, of the dimorphism of *Dictyonema*. In support of his suggestion, Allman points out that in the genus *Antennularia* the embryonic stem is provided with nematophores before any hydrothecae have made their appearance. Wiman (1895, pp. 305–6) expressed the opinion —to some extent corroborated by the evidence here afforded by *D. flabelliforme*—that *Dictyonema* is more likely to be derived *from* the Graptoloidea than *vice versa*, in which case the bithecae must be regarded, not as a relic of a previous condition, but as an addition to the organization of the colony, and thus they cannot be held to represent hydrothecae which are suppressed in the Graptoloidea.

(*c*) *The Dissepiments.*

The dissepiments are skeletal bars which serve to connect adjacent stipes, their function being probably as much to keep the stipes apart as to hold them together. Certain sections (Fig. 2, sections d and e) demonstrate that they are really hollow, but they are in many cases so much flattened by compression in the plane of the net-work that the two sides are in contact and they then appear as thin strap-like bands. It seems reasonable to suppose that they were originally thin-walled hollow cylindrical bars (Fig. 8). They widen out considerably at the points of attachment to the stipes. In specimens from this locality (*a* 26) they are fairly regularly distributed, occurring usually at the level of every second hydrotheca, and generally at right angles to the stipes so as to give a characteristically rectangular mesh with the average dimensions: 1·4 mm. (long) × 1·2 mm. (wide). This mesh-work may, however, be irregular, at least in parts.

The mode of origin of the dissepiments is a matter of some interest. Specimens of *D. cervicorne* figured by Holm (1890, plate i, fig. 4) show dissepiments with a central knot, suggesting the point of fusion of two growths, and further the dissepiments are often angular. In *D. flabelliforme* there is no evidence of fusion, and the bars are perfectly straight, so that they must be regarded as developed by outgrowths from a stipe on one side, which meet and fuse with the adjacent stipe at some point. This method of origin naturally accounts for any irregularities in the angle of divergence from the stipe (which angle is normally 90°). Sections show that the dissepiments may be attached to (*a*) a bitheca; (*b*) either the initial or the maturer portion of a hydrotheca; or (*c*) to a " special chamber " (represented by " x " in Fig. 2).

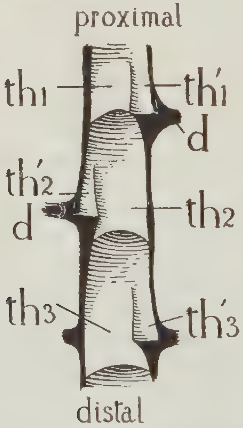

Fig. 7.—Diagrammatical vertical section showing hydrothecae and bithecae, with dissepiments. The inner walls of the thecae rise distally towards the plane of the section by which they are eventually truncated. Cf. Fig. 3 A.

Examination both of sections and isolated specimens of *Dictyonema*, seems to show that a dissepiment is always attached to a bitheca at one end or the other; it is therefore a logical inference that they are primarily to be regarded as developed by outgrowths from the bithecae; and the production of portions of the skeletal framework is not altogether incompatible with the other functions that have just been attributed to their living occupants as dactylozooids.

Where the stipes show a precisely similar disposition of hydrothecae and bithecae, the type of mesh is that represented in Fig. 9 A, but where the bithecae are opposite one another on the adjacent stipes, the type of mesh is that of Fig. 9 B. In conjunction with the evidence previously adduced, this makes it fairly certain that the dissepiments grew out of the bithecae along any given stipe on one side only, and met, according to the arrangement on the other stipe, a hydrotheca or another bitheca. It is difficult, however, to carry a suggestion of this nature beyond mere surmise.

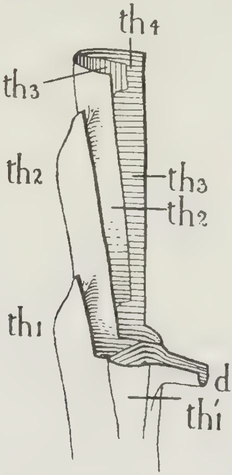

FIG. 8.—Diagrammatical Reconstruction of part of a branch of *D. flabelliforme*. $th_1, _2$, etc. = hydrothecae; th'_1 = bitheca; d = dissepiment.

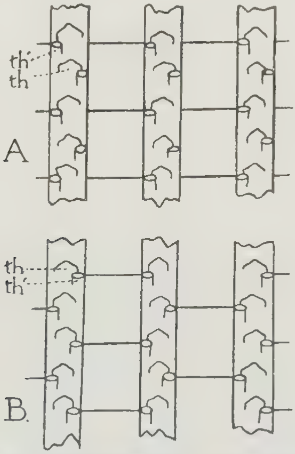

FIG. 9.—Diagrams showing the disposition of dissepiments in *D. flabelliforme* and their relation to the arrangement of the bithecae along the stipes. A, bithecae in corresponding positions along the stipes. B, bithecae opposite one another along the stipes. (Type A is by far the commoner, and type B is generally found as a junction of two sets of type A.) th = hydrothecae; th' = bithecae.

The explanation of the "special chambers" is possibly to be found in the development, where an outgrowing dissepiment met the adjacent stipe, of a little mass of protoplasm which encased itself in perisare. The inner wall of one of these chambers would, on this explanation, be the original outer wall of the stipe. On the other hand, it may be that they are merely due to the development, at this point, of a strengthening lamella in the cavity of either a hydrotheca or a bitheca. Such lamellae seem occasionally to be more or less promiscuously developed. (Fig. 2, sections e, i, and l.)

V. COMPARISON OF THE STRUCTURE OF *D. FLABELLIFORME* EICH. WITH THAT OF *D. RARUM* WIMAN.

The question of the relation of these forms to one another is one of considerable interest, as there can be no doubt whatever that the types of structure exhibited are absolutely distinct.

Externally, *D. flabelliforme* is, as mentioned previously, characterized by the absence of any real approach to that spiral arrangement of the cell groups obtaining in *D. cervicorne*, and it is regarded as doubtful whether the structure of the Tremadocian species will bear the interpretation which might at the outset be put upon it, viz. that it is ancestral to the spiral of the Silurian species.

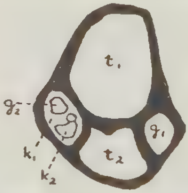

Fig. 10.—Transverse section of *D. rarum* (after Wiman). t_1, t_2 = hydrothecae (with nourishing individuals); g_1, g_2 = gonangia; k_1, k_2 = budding individuals.

How the true spiral came to be evolved it is at present impossible to conjecture, but it is certainly an expression of an angular change in the direction of thecal growth which is continuous, while in the condition characterizing *D. flabelliforme* the change is rhythmically discontinuous. Externally, therefore, *D. flabelliforme* resembles, to some extent, the Silurian *D. rarum*, where there is also little trace of a spiral arrangement of the cell groups.

Concerning internal structure, perhaps the most important point is that *D. rarum* not only shows a well-defined common canal, separately encased, but the mode of origin of the thecae from this is of such a nature as to lead Wiman to postulate the existence within it of a third type of individual—the budding individual (Fig. 10, k_1, $_2$)—in which he locates the entire growth of the colony. Each budding individual gives rise to a hydrotheca, a gonotheca, and another budding individual—a type of budding possibly analogous to the calycinal budding of certain corals. The presence of this third type of individual need not be regarded as placing an insuperable barrier between the two species, though it does suggest that they might be generically distinct. The budding individual is conceivably derivable from the condition of hydrothecal budding obtaining in *D. flabelliforme* through the interpolation of an intermediate stage possessing a definite common canal.

It is doubtful whether the "bithecae" of *D. flabelliforme* are absolutely homologous with the "gonangia" of *D. rarum*. The "bithecae" are lateral to the hydrothecae—or even somewhat superficial—throughout their entire length, while the "gonangia" are developed on one side of the stipe and pass internally between the hydrothecae and the common canal to the other side of the stipe, on which they open; i.e. while the "bithecae" are entirely external the "gonangia" are very largely internal. The shifting back of their points of origin to the budding individual would naturally occur *pari passu* with the formation and separation of the common canal—accepting some such condition as intermediate between *D. rarum* and *D. flabelliforme*.

Finally, the complexity of the organization of the branch is further increased by the tendency for the individuals to be differentiated at an earlier stage and yet remain attached for a longer period before opening at the surface.[1] Thus, in some sections of *D. rarum* Wiman records the presence, simultaneously, of nine individuals, while in *D. flabelliforme*, the number never exceeds four.

All the facts, therefore, tend to show that in *D. flabelliforme* we are dealing with a primitive set of characters, such as would be expected from the low stratigraphical horizon, but whether these characters are ancestral to those found in e.g. *D. rarum*, or whether the genus *Dictyonema* is really a polyphyletic assemblage of forms, is a point which can only be definitely decided by work on the structure of the stratigraphically intermediate forms, which may then prove to be structurally intermediate as well.

VI. EARLY DEVELOPMENTAL STAGES IN *D. FLABELLIFORME*.

(*a*) *The Sicula*.

Only one specimen showing the sicula and early growth stages has been obtained from locality *a* 26, and it is represented in Fig. 11 below. Other examples have been obtained from beds just above and below—within 15–20 feet.[2] As it is unlikely that any important structural changes manifest themselves in this thickness, these specimens have been used to amplify, in a confirmatory manner, the principal points of the following description.

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[1] This condition appears to be still more marked in *Ptilograptus*; referring to *P. suecicus* Wiman, Wiman states (1896, p. 247): "The only difference between this genus and, say, *Dictyonema*, will thus be seen to consist in the individuals here being kept together for some time, so as then to open in alternate groups which I call twigs."

[2] The actual thickness of the whole *Dictyonema* zone is considerably more in this area.

The sicula is provided with a long fine nema, but in the present example this has been broken away. The sicula itself is more or less conical, slightly curved, and possessed of a stout apertural spine or virgella. The maximum width appears to be reached at about its mid-length, but the actual shape of the later portion of the sicula is much obscured on nearly all sides by the initial portions of the various thecae which take their origin around it.

(*b*) *Subsequent Development.*

The first hydrotheca (thl^1, Fig. 11) appears at an early stage from the virgella side of the sicula and remains adherent to it for a considerable distance, finally diverging at an angle of about 75°. At quite an early stage it gives off, on one side, a short branch (z) which remains in contact with it and with the sicula throughout its length, and is apparently without any opening to the exterior. At a very slightly later stage, it gives off the hydrotheca thl^2 (Fig. 11) on the other side.

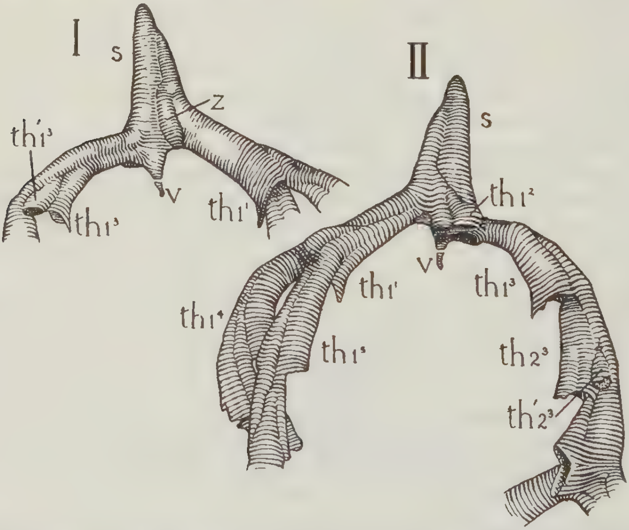

Fig. 11.—Early growth stages of the colony in *D. flabelliforme*. I, obverse; II, reverse. S = Sicula, V = Virgella, thl^1 = first formed, hydrotheca; thl^2, thl^3, thl^4, and thl^5 = hydrothecae; th^{1}l^3, th^{1}2^3 = bithecae; z = ? bitheca. (× 18.)

It is of considerable interest to note that the mode of origin of thl^2 from thl^1 may be either "right-handed" or "left-handed". This is a primitive feature, since it indicates that there is no localization of growth potentiality. "z" (Figs. 11 and 12) may possibly be a bitheca associated with thl^1, but as mentioned previously it does not open to the exterior, and it is produced slightly *before* the hydrotheca thl^2 is given off (characteristically in the later stages a bitheca is produced after, not before, the next hydrotheca). Further, Fig. 12 shows that $th1^1$ is provided with what is more likely to be a true bitheca in a more normal position. Another possibility is that it is a portion of the obverse side of the crossing canal. As is the case with the origin of $th1^3$ (to which reference is made below) this is a point which can only be definitely settled by sectioning —a process at present precluded by the insufficiency of suitable material.

$Th1^1$ in Fig. 11 divides immediately to give rise to $th1^4$ and $th1^5$. In some other specimens (e.g. Fig. 12) this division does not occur until after the formation of $th2^1$ or even $th3^1$—indeed the actual stage at which any of these "primary branches" divide does not appear to be absolutely constant. The angle of divergence of $th1^1$ and its immediate division into $th1^4$ and $th1^5$ corresponds exactly with the description given by Ruedemann (op. cit., pp. 602–3) of the development of *D. flabelliforme* in material from Schaghticoke, U.S.A.: it will be seen later that the other stages cannot be so readily paralleled. Ruedemann states: ". . . a lateral bud appears which, after a short adherence to the sicula, diverges under a very large angle (about 75°). This theca almost immediately divides as it appears, both resulting thecae diverging about equally. Next a third theca is noticed, all three being so arranged as to form a tripod, and a fourth theca, apparently branching from the third, quickly completes the original group of four thecae."

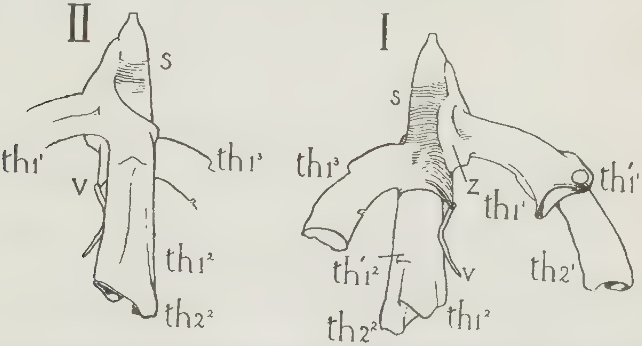

FIG. 12.—Early developmental stages in *D. flabelliforme* showing transverse growth lines of the apertural portion of the sicula. (× 18.) Lettering as in Fig. 11. This specimen is from Loc. *a* 26 (17), 2 ft. above *a* 26.

$Th1^2$ is unfortunately broken off short in the specimen represented in Fig. 11, but in the majority of the other specimens it appears to divide immediately.

$Th1^3$ is presumably derived from the inner side of the crossing canal, though the general appearance is in all cases rather suggestive of its origination independently from the apertural portion of the sicula. Short of the actual proof of a separate aperture to the sicula, thl^3 must be assumed to be derived from the inner side of the crossing canal, in a manner analogous to that of several of the *Dichograptids*. It would appear from an examination of these Shineton specimens, that the "third" and "fourth" thecae of Ruedemann really antedate the "first" and "second", the order of development being :—

(*a*) The first hydrotheca thl^1 produced on the virgella side of the sicula.

(*b*) The second hydrotheca thl^2 developed at an early stage from thl^1, and lying over the aperture of the sicula.

(*c*) The third hydrotheca thl^3 arising from the inner side of the crossing canal.

The subsequent division of these hydrothecae appears to be a trifle indefinite ; the third branch does not appear to divide until after the development of th3^3 ; the division of the second branch is usually immediate (after thl^2), while the division of the first branch may be after thl^1 or th3^1.

Dissepiments are not present until a point about 0·3 cm. from the sicula is reached ; they are not present with their normal frequency for a further distance of 0·5 cm.—a fact recorded by Brögger (op. cit.).

VII. SUMMARY.

The more important points in connexion with the structure of *D. flabelliforme* are :—

1. The absence of any real approach to the spiral arrangement of the thecae along the stipes.[1]
2. The absence of a common canal ; and the consequent budding of each hydrotheca direct from the preceding one.[1]
3. The initial constriction of each hydrotheca cavity.
4. The budding of the bithecae from the sides of the hydrothecae along which they lie.
5. The early stage at which the presence of the bithecae is observed.
6. The derivation, indifferently "right-handed" or "left-handed" of the crossing canal.
7. The nature of the dissepiments—hollow bars derived principally as outgrowths of the bithecae.

It cannot be over-emphasized that as one of the earliest dendroid graptolites, *D. flabelliforme* shows more marked affinities with the Graptoloidea than any of the later Dendroids. It appears to differ from the Graptoloidea in those points which, in later forms, may become subject to increased specialization—namely, the earliest traces of the spiral arrangement of the cell groups, and the division of labour by modification of individuals for definite functions.

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[1] These facts afford confirmation of Dr. Elles' statement respecting *D. flabelliforme* : " . . . a most interesting form, uniting as it does the characters of both Graptoloidea and Dendroidea." "The Graptolite Faunas of the British Isles": *Proc. Geol. Assoc.*, 1922, p. 176.

In conclusion, I wish to express my thanks to Dr. G. L. Elles, Professor W. W. Watts, Professor D. M. S. Watson, Dr. A. M. Davies, Mr. G. S. Sweeting, and to my colleague, Mr. C. J. Stubblefield, from all of whom I have received a great deal of valuable advice and criticism. To the Beit Trustees I am also indebted for the grant which made this work possible.

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Some New Silurian Trilobites

By F. R. COWPER REED, Sc.D., F.G.S.

(PLATE II.)

Genus LICHAS Dalman.

Subgenus AUTOLICHAS Reed.

Lichas (*Autolichas*) *silvestris* sp. nov. (Pl. II, Fig. 1.)

PYGIDIUM elongated, sublanceolate, bluntly pointed posteriorly. Lateral lobes flattened, horizontal, composed of three pairs of pleurae and a median postaxial piece. Axis short, conical, convex, tapering rather rapidly to blunt tip, less than one-third the length of the pygidium and about one-third its width, subcarinate posteriorly, faintly marked off from postaxial piece by weak circumscribing furrow; furnished at anterior end with one strong narrow complete ring, marked off by strong furrow, followed by weaker second ring defined by faint complete furrow, and with traces of a third incomplete ring; posterior two-thirds of axis devoid of annulations. Postaxial piece long, narrow, widening somewhat posteriorly, descending gradually to level of lateral lobes from tip of axis and becoming flattened but distinctly carinated for its whole length. First lateral pleura strongly falcate, bending back suddenly at fulcrum where it is widest and thence narrowing rather slowly to acutely pointed free tip projecting backwards beyond margin; pleural furrow submedian, diagonal, parallel to posterior edge of pleura, running nearly to tip. Second lateral pleura elongate, sublanceolate with tip bent back slightly and projecting freely beyond margin as short recurved point; pleural furrow median, slightly diagonal, not reaching tip. Third lateral pleura sublanceolate, broader than second pleura, incompletely marked off from postaxial piece posteriorly, the bounding furrow not quite reaching the margin but curving gently outwards at its end; tip of pleura undefined and not projecting beyond margin; pleural furrow median, slightly wavy, running nearly straight back parallel to its fellow, curving inwards a little at its end but not clearly connected with bounding furrow. All pleural and interpleural furrows of equal strength. Posterior lateral margins of pygidium behind tips of second pleurae forming nearly half its length and describing a long simple slight curve on each side, uniting behind in a blunt point at about 60°, the median carina of the postaxial piece extending to its tip.

Surface of pygidium ornamented with rather coarse tuberculation, the tubercles being of 2 or 3 sizes, and the largest ones numerous.

Dimensions.—

Length of pygidium . . .	23·0 mm.
Width of pygidium at front end .	18·0 ,,
,, ,, ,, across middle	22·0 ,,
Length of axis	9·0 ,,
Width ,, ,, ...	6·5 ,,

Horizon and locality.—Mulloch Hill Group, Mulloch Wood, Girvan.

Remarks.—This pygidium, which was collected by Mrs. Gray in 1922, seems to be almost identical with the one from the Coniston Limestone described by McCoy,[1] first as "*L. propinqua* Barrande ?" but to which he subsequently (in a footnote to the Plate) gave the name *subpropinqua*, on learning that the apex of the pygidium in Barrande's species was "notched" (i.e. that the last pair of pleurae had free ends). McCoy's species is now generally referred to the Scandinavian *L. laciniatus* Wahl.,[2] so that if this identification is correct McCoy's name must be dropped. On a comparison of our specimen with this Coniston pygidium in the Sedgwick Museum it is noticeable that ours has a more pointed apex, a more marked angular carination along its whole length, and a longer non-annulated portion of the axis, so that its specific identity can hardly be maintained. In addition to this, it occurs in Llandovery and not Bala beds; but it may be remarked that the whole group comprising *L. laciniatus* Wahl., *L. affinis* Ang.,[1] and *L. conformis* Ang.,[2] of which the two latter have been recorded from the Keisley Limestone,[3] are specially characteristic of the Ashgillian; and these have recently been assembled by the present author in a new subgenus under the name *Autolichas*.[4] *L. affinis* has previously [5] been put into the subgenus for which Gürich's name *Metopolichas* was employed, the type of which is *L. hübneri* Eichw., but it was then expressly stated that *L. affinis* and its allies only "appear to belong to it" and that in them the third pleurae of the pygidium have lost their points. Foerste [6] rightly points out that there is no evidence that *L. hübneri* has the same type of pygidium as *L. affinis*, and he is of the opinion that the American Silurian species usually referred to the subgenus *Metopolichas*, such as Weller [7] described, do not belong to it, but are typical members of *Lichas* itself, of which *L. laciniatus* Wahl. is the genotype. The pygidium seems to have much the same kind of pleural and interpleural furrows as the subgenus *Homolichas*, using this term in the sense intended by Schmidt,[8] but unfortunately in its type-species, *L. depressus* Ang., it is uncertain whether the posterior margin of the pygidium had free projecting ends to all the pleurae or only to the first two pairs.

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[1] McCoy, *Syn. Brit. Pal. Foss. Woodw. Mus.*, p. 150, pl. i F, figs. 17, 17*a*.

[2] Angelin, *Palaeont. Scand.*, p. 73, pl. xxxvi, fig. 1.

No other Girvan species from Mulloch Hill can be assigned to this subgenus, but in the case of another Girvan form from Woodland Point (Middle Llandovery) described by the present author [9] as *L.* (*Metopolichas*) aff. *marginatus* Lindström, we may suspect that it should be referred to *Autolichas* on the strength of the resemblance of its head-shield to *L. affinis*, but we do not know its pygidial characters.

Foerste (op. cit.) is of opinion that members of this *Autolichas* type first made their appearance in America in the Medinan, and are restricted to the central States. We have previously pointed out that in the British Isles (and probably in Northern Europe) they are typical of the Ashgillian, and we can now add that they occur also in the Lower Llandovery as represented in the Girvan area.

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[1] Ibid., p. 69, pl. xxxvi, fig. 2*a*; pl. xxxviii, fig. 4*b*.

[2] Ibid., p. 74, pl. xxxviii, fig. 5.

[3] Reed, *Q.J.G.S.*, lii, 1896, p. 427, pl. xxi, fig. 10.

[4] Reed, GEOL. MAG., vol. lx, 1923 (October), p. 458.

[5] Reed, *Q.J.G.S.*, vol. lviii, 1902, p. 73, fig. 5.

[6] Foerste, *Amer. Journ. Sci.*, vol. xlix, 1920, p. 35.

[7] Weller, *Bull. Chicago Acad. Sc.*, iv, pt. ii, 1907, pp. 242–6, pl. xxi, figs. 1–4; pl. xxii, figs. 12–13.

[8] Schmidt, *Mem. Acad. Impér. Sc. St. Petersb.*, xxxiii, No. 1, Abt. 2, 1885, p. 96.

[9] Reed, *Lower Palaeoz. Trilob. Girvan*, pt. iii, 1906 (Palaeont. Soc.), p. 104, pl. xiv, figs. 15–16?

Genus ACIDASPIS Murchison.

Subgenus Primaspis Richter.

Acidaspis (*Primaspis*) *reperta* sp. nov. (Pl. II, Figs. 2, 2*a*.)

Middle-shield transversely semi-elliptical, truncate in front, the pre-glabellar margin being nearly straight; anterior border very narrow, forming thin rounded band. Glabella broadly semi-oval, truncate in front, composed of subcylindrical median lobe having slight independent convexity, and three pairs of lateral lobes, slightly depressed, but not cut off from median lobe by longitudinal furrows; axial furrows strong, divergent and nearly straight to middle of basal lobes of glabella, then curving in sharply to base. Anterior lateral lobes very minute, represented by small oblique tubercles; second lateral lobes sub-elliptical; third lateral (basal) lobes larger than others, subtriangular, rounded. First lateral furrows represented by small pits; second lateral furrows short, oblique, ending internally in deep pits; third lateral furrows oblique, parallel to second furrows, longer, ending internally in deep pits. Occipital furrow strong, straight in middle, but curving back slightly behind basal lobes of glabella. Occipital ring very broad, transversely suboblong in shape, extending to middle of base of basal lobes, with each posterior lateral angle furnished with a long stout spine directed backwards and slightly outwards and gently curved downwards, nearly as long as whole head-shield and making an angle of about 130° with its posterior edge; a single median short stout spine is also present near the posterior margin of the occipital ring, projecting backwards, with a deep pit on each side. Pleuro-occipital ring very narrow, horizontal. Fixed cheek represented by narrow rounded ridge alongside glabella, slightly widening posteriorly and gently arched. Palpebral lobe forming a similar rounded but narrower outer ridge. Eyes situated far back, level with occipital furrow. Surface of middle-shield ornamented with a few rather large tubercles, forming 5 or 6 irregular longitudinal rows on the median lobe of the glabella, with 2 or 3 rather larger ones on the basal lobes, one or two on the second lateral lobes, and a single row of 5–8 along the cheek ridge and palpebral lobe; on the neck ring there are two large tubercles on each side of the median occipital spine, and the lateral occipital spines are ornamented with a few smaller ones.

Dimensions.—

Length of middle-shield	. .	2·5 mm.
Width of middle-shield at base	.	3·7 ,,

Horizon and locality.—Saugh Hill Group (M. Llandovery), Newlands, Girvan.

Remarks.—This species is represented by only one minute middle-shield of which the external impression as well as the internal cast is preserved. It was collected by Mrs. Gray in 1922, and is certainly distinct from any Girvan form previously described.

The body-ring from Newlands mentioned by the author in 1906[1] as possibly referable to *A. callipareos* Wyv. Thoms., is the only fragment of the genus previously known from this locality.

As regards the subgeneric position of this new species we may certainly refer it to the newly formed subgenus *Primaspis* Richter,[2] the characters of which will be discussed shortly in a paper by the present author on the classification of the *Acidaspidae.*

With regard to its specific affinities the head-shield appears to bear a considerable resemblance to the one from the Whitehouse Group, attributed by the author to *A. playfairi* Reed,[3] but probably it is also nearly allied to *A. quinquespinosa* Salt.[4]

Subgenus LEONASPIS Richter.

Acidaspis (*Leonaspis*) sp. (Pl. II, Fig. 5.)

There is one small free cheek of a species of *Acidaspis* from the Lower Ludlow bed of the Woolhope area, recently collected by Mr. C. I. Gardiner, F.G.S., which deserves a special description, as it shows features indicating a new species.

The cheek is subtriangular in shape, forming nearly the quadrant of a circle. The anterior branch of the facial suture is very long and subparallel to the axis, describing a gentle outward curve from the front margin to the eye, which is situated very far back at the inner posterior angle of the cheek and is of rather large size and prominent, resting on an elevated base. The general surface of the cheek from the eye to the marginal furrow is gently convex and bears on its surface 6 or 7 fairly regular radiating rows of 4–6 small subequidistant tubercles, with traces of short submarginal irregular radial grooves between them, but the posterior outer angle of the cheek is smooth. The border which is marked off by a strong marginal furrow is broad and rounded and is continued back into the stout rounded genal spine which bends slightly outwards, making a distinct angle with the outer edge of the cheek. The genal spine has its terminal portion broken off in our specimen, so that its true length cannot be ascertained, but near its base are one or two small spinose projections on its outer and inner edges. The outer edge of the border of the cheek is furnished with spines gradually increasing in size from the front to the back; the anterior 4 or 5 are small and short and seem to bend slightly upwards, but the succeeding 7 are stouter, curve gently backwards, lie in the general plane of the head-shield, and have their bases contiguous. The posterior and longest spine of the series lies level with the occipital furrow. The border is smooth inside the anterior 4 or 5 marginal spines, but behind them bears a median row of 5 subequidistant large tubercles followed by two similar ones on the basal part of the genal spine; none of these tubercles correspond with the marginal spines. The pleuro-occipital furrow is strong, deepening laterally, and meets the marginal furrow at an angle of about 75°. The posterior branch of the facial suture curves widely outward behind the eye, cutting the posterior margin at the base of the genal spine.

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[1] Reed, *Lower Palæoz. Trilob. Girvan,* pt. 3, 1906, p. 112.

[2] Richter, *Centralbl. f. Miner.*, etc., Jahrg, 1917, No. 21, p. 462 et seq., text-fig. 3.

[3] Reed, *Lower Palaeoz. Trilob. Girvan,* Suppl., 1914, p. 35, pl. vi, figs. 5–6.

[4] Lake, *Quart. Journ. Geol. Soc.*, vol. lii, 1896, p. 240, pl. vii, figs. 3–4.

Dimensions.—Length of free cheek, 3·5 mm.

Horizon and locality.—Lower Ludlow. Near Wooton Farm, one mile N.E. of Mordiford.

Remarks.—The affinities of this free cheek are with members of the group *Leonaspis* as defined by Richter,[1] rather than with *Primaspis.* But no British Silurian species [2] is closely allied to it. The ornamentation of the surface and distribution of the tubercles on the cheek and border are peculiar, but the course of the facial sutures and general characters of the cheek and marginal and genal spines suggest relations with *A. leonhardi* Barr.

Genus ENCRINURUS Emmrich.

Encrinurus magnituberculatus sp. nov. (Pl. II, Figs. 3, 3*a*.)

Pygidium subtriangular, acutely pointed behind at about 60°, the sides converging to the blunt apex. Axis conical, broad, tapering at about 25°, composed of 8–9 simple complete rounded prominent rings and 1–2 smaller narrower ones at apex; the first ?, second and third rings bear a median pair of large rounded prominent tubercles with two much smaller ones on each side, the next two rings have a single prominent median tubercle with one or two smaller lateral ones, the next ring bears a pair of median tubercles, and the last four or five rings have three large tubercles of which the median one is the largest. The one or two small terminal rings are indistinct.

Pleural lobes strongly arched down on each side, more so posteriorly, composed of seven simple strongly rounded unfurrowed pleurae, not corresponding with the axial rings, becoming successively more curved backwards posteriorly so that the last 2–3 lie subparallel to the axial line; each pleura bears a prominent tubercle near its base; ends of pleurae bluntly rounded, free, short, somewhat swollen; interpleural furrows, deep, strong, nearly as wide as pleurae. Articulating facet on lateral lobes large, triangular, flattened. General surface of pygidium finely granulated.

Dimensions.—Length 11 mm.
Width at front 12 mm.

Locality and horizon.—Wenlock Limestone. Buckenhill Wood, one mile S.S.W. of Woolhope.

Remarks.—There is only one specimen of this species collected by Mr. Gardiner and consisting of the above described pygidium which has the axis and left lateral lobe in a good state of preserva-

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[1] Richter, *Centralbl. f. Miner.*, etc., Jahrg. 1917, No. 21, p. 465, text-fig. 2.

[2] Lake, *Quart. Journ. Geol. Soc.*, vol. lii, 1896, pp. 235–45, pls. vii and viii.

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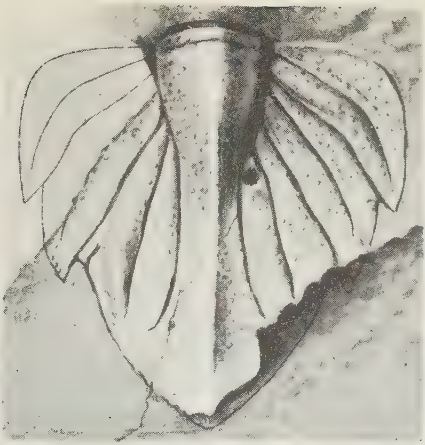

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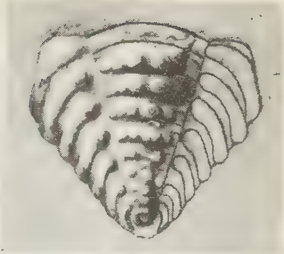

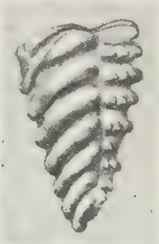

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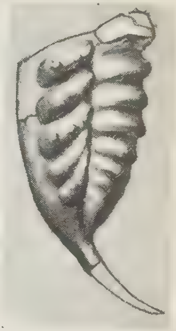
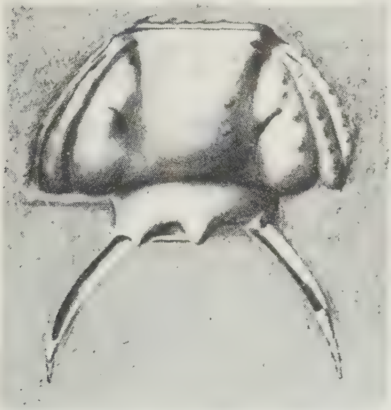
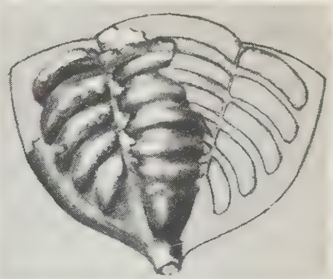
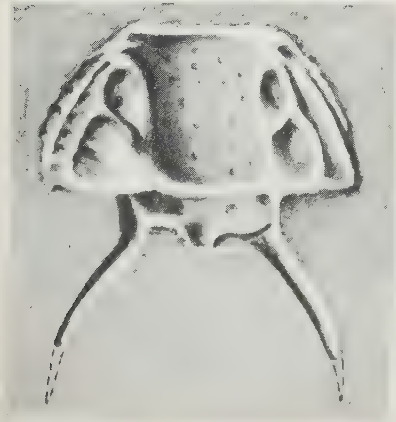


4a

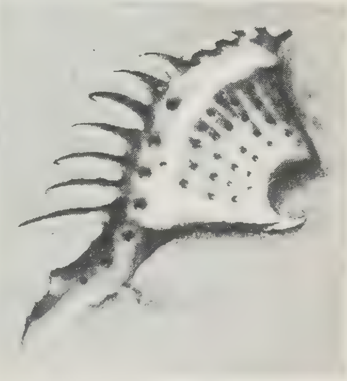




4



2a



5

NEW SILURIAN TRILOBITES.

[To face p. 72.

tion, but the first axial ring is partly broken off, so that the arrangement of the tubercles on it is unknown.

The comparatively few, but complete, axial rings with their coarse but regularly arranged tubercles and the possession of a single prominent basal tubercle on each pleura are distinctive features.

The nearest allies seem to be *E. indianensis* Kindle[1] and *E. tuberculifrons* Weller[2] of the American Silurian; the former has a rather similar tuberculation of the axial rings.

No British species hitherto described approaches our new Woolhope form at all closely. The pleural ribs in number and character suggest the Wenlock species, *E. variolaris* Brongn.,[3] but the axial annulation and tuberculation are quite different. The small number of pleurae is a feature, however, which is met with in several American species, but none of the Australian species described by Etheridge and Mitchell[4] show many points of similarity. Vogdes[5] would apply and restrict Eichwald's name *Cryptonymus* (1840) to this group having few pleurae and only 9–15 rings on the axis. Raymond[6] would separate off the author's *Encrinurus octocostatus* Reed[7] (from Glensaul) together with *Amphion Westoni* Billings, to form a new genus under the name *Ectenonotus*. Beecher considered *Cromus* Barrande to be included within the limits of *Encrinurus*, and certain species of *Cybele* are very closely allied. It seems, therefore, that the genus *Encrinurus* is capable of subdivision, at any rate into subgenera.

Genus PHACOPS Emmrich.

Phacops (*Acastella* subgen. nov.) *macrocentrus* sp. nov. (Pl. II, Figs. 4, 4*a*.)

Pygidium broadly subtriangular with gently arched sides and posterior extremity suddenly produced into a cylindrical spine, curving upwards and not lying in the general plane of the pygidium. Axis prominent, rounded, subconical, tapering gradually to bluntly rounded end, descending abruptly to concavity of border at base of spine; annulated for greater part of its length by 6 or 7 prominent rounded rings (the two anterior ones are broken and imperfect in the specimen) followed by an eighth indistinct one, and a short terminal rounded piece, apparently devoid of rings; each ring bears a small median tubercle. Lateral lobes strongly arched down, convex, bearing 5 or 6 pleurae on each side (only 5 pleurae are preserved in the specimen), ending rather abruptly at inner edge of border and corresponding to the rings on the axis; pleurae strong, simple, rounded, unfurrowed, gently curved, subcarinate in inner part, and bearing a few tubercles; small triangular smooth area behind last pleurae on each side of tip of axis. Interpleural grooves, deep, strong, equal. Border of pygidium somewhat flattened, but not horizontal, of uniform width, finely granulated, without marginal furrow.

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[1] Kindle, *28th Ann. Rep. Indiana*, 1904, p. 482, pl. xxiv, figs. 14–15; Raymond, *Bull. Mus. Comp. Zool.*, lx, No. 1, 1916, p. 26.

[2] Weller, *Bull. Nat. Hist. Surv.*, Chicago Acad. Sc., iv, pt. ii, 1907, p. 259, pl. xxiv, figs. 12–13; Raymond, op. cit., p. 26.

[3] Raymond, op. cit., p. 26; Vogdes, *Trans. San Diego Soc. Nat. Hist.*, vol. i, No. 2, 1907, pp. 61–77, pls. 1–3.

[4] Etheridge and Mitchell, *Proc. Linn. Soc. N.S. Wales*, xl, pt. iv, 1915, pp. 646–80, pls. liv–lvii.

[5] Vogdes, op. cit., p. 74.

[6] Raymond, *Bull. Mus. Comp. Zool.*, vol. lxiv, No. 2, 1920, p. 295.

[7] Reed, *Quart. Journ. Geol. Soc.*, vol. lxvi, 1910, p. 277, pl. xxii, figs. 4*a*, 4*b*.

Dimensions.—

Length of pygidium to base of terminal spine 8 mm.
Width at front end 12 mm.

Horizon and locality.—Upper Ludlow, Prior's Frome, near Woolhope.

Remarks.—The one specimen of this interesting trilobite which was collected by Mr. Gardiner consists of a pygidium having the right half buried in matrix and the anterior margin imperfect. Probably one or two segments are missing, so that only five pleurae are distinctly preserved, and only 5 axial rings are perfect, the one or two at the front end being broken, and only dimly traceable. But the whole left lateral lobe and the axis (with these exceptions) are complete and free of matrix (though the actual shell is missing), and the basal part of the terminal spine is well seen, so that judging from its rate of tapering it probably had a length equal to nearly half the pygidium.

The species is undoubtedly new, and may be appropriately named *macrocentrus* from its long terminal spine. With regard to its generic position and specific affinities we may draw attention to its resemblance to the pygidium from the Siluro-Devonian of Mondrepuits which was originally described as *Dalmanites heberti* by Gosselet; the type has been figured by Barrois[1] who identifies this species with the variety *spinosa* Salter[2] of *Phacops downingiae* (Murch.) founded on a head-shield, and he elevates it to specific rank as *Acaste spinosa* Salt. Leriche[3] had previously given a clear outline restoration of the head-shield and pygidium of the Mondrepuits form under the name of *Acaste downingiae* (Murch.), but remarked that it reproduced exactly the characters of the British Ludlow variety termed *spinosa* by Salter. The pleurae are represented in this drawing as simple and unfurrowed which is a feature in our new species, but they seem to be flattened, devoid of tubercles and separated by weaker furrows. For these reasons we cannot regard Leriche's form as identical with ours. As regards the reference of either of them to Goldfuss'

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[1] Barrois, Pruvost and Dubois, "Faune siluro-devon. Liévin. (Pas de Calais)": *Mem. Soc. Geol. Nord.*, vi, ii, fasc. 2, 1920, pp. 121, 160, pl. xv, figs. 6–7; pl. xvii, figs. 1–2.

[2] Salter, *Mon. Brit. Trilob.*, p. 27, text-fig. 7.

[3] Leriche, "Faune Gedinnien infér. de l'Ardenne": *Mem. Mus. Roy. Hist. Natur. Belgique*, vi, 1912, p. 47, text-figs. 4–5, pl. iii, figs. 8–9.

Acaste (recently redefined by Wedekind[1]) there are important points of difference, for *Acaste* has typically not only rounded genal angles, but a non-mucronate pygidium, an entire simple margin and furrowed pleurae. Indeed, the Lower Devonian subgenus *Anchiopella*[2] possesses more of their characters, and Hall[3] particularly mentions the usual absence of "duplication" (=pleural furrows) on the pygidial pleurae of the type species *Dalmanites anchiops*, so that we may perhaps regard these species as early representatives of this Devonian subgenus. The Canadian species *D. Logani* Hall, described by Hall (1860) and Dawson[4] from the Silurian (Stonehouse Formation=Upper Ludlow)[5] of Nova Scotia, seems also to belong to the same group as "*Acaste*" *spinosa* and our new species. We may suggest for this group the name *Acastella* and regard it as of subgeneric rank. The definition of this new subgenus will be as follows: head-shield like *Acaste* Goldfuss, except that the genal angles are provided with spines. Pygidium of few segments; posterior extremity furnished with median spine; pleurae few, simple, without furrows; border well defined. Type *A. spinosa* Salter.

The classification of the *Phacopidae* is continually needing revision as our knowledge of its various members increases, and the introduction of new generic or subgeneric names becomes necessary. Since the present author put forward his scheme of classification in 1905, Wedekind (op. cit.), McLearn,[6] Richter,[7] and others, have proposed various modifications and additions, and a review of their work in the light of recent discoveries is in preparation.

ADDENDUM, JANUARY, 1925. Since the above article was written in 1923 McLearn ("Palaeont. Silur. Rocks, Arisaig, N. Scotia," *Mem.* 137 *Geol. Surv. Canada*, 1924, pp. 166–8, pl. xxvii, figs. 3–6) has placed *D. logani* Hall in the genus *Dalmanitina*, of which *D. socialis* Barr. is the type. But the present author does not accept this view.

EXPLANATION OF PLATE II.

FIG.

1.—*Lichas* (*Autolichas*) *silvestris* sp. nov. Pygidium. × 2½. Mulloch Hill Group, Mulloch Wood, Girvan. Mrs. Gray's Collection.

2.—*Acidaspis* (*Primaspis*) *reperta* sp. nov. Cranidium. × 9. Saugh Hill Group, Newlands, Girvan. Mrs. Gray's Collection.

2*a*—Ditto. Natural impression of same specimen. × 9.

3.—*Encrinurus magnituberculatus* sp. nov. Pygidium. × 2½. Wenlock Limestone, Buckenhill Wood, near Woolhope. Mr. C. I. Gardiner's Collection.

3*a*.—Ditto. Side view of same specimen. × 2½.

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[1] Wedekind, *Abh. k. preuss. geol. Landesanst. N.F.* Heft 69, 1914, p. 40.

[2] Reed, GEOL. MAG., 1907, p. 169; Clarke, "Foss. devon. Parana": *Mon. Serv. Geol. Miner. Brasil*, vol. i, 1913, pp. 147, 154.

[3] Hall, Palaeont. New York, vol. vii, 1888, p. 59, pl. ix, figs. 1–6, 10, 12, 13; pl. x, figs. 1–14.

[4] Dawson, *Acadian Geology*, 1865, p. 607, text-fig. 215.

[5] Williams, *Mem. 60, Geol. Surv. Canada*, 1914, pp. 72–3.

[6] McLearn, *Ottawa Naturalist*, vol. xxxii, 1918, pp. 31–6.

[7] Richter, *Senckenbergiana*, Bd. v, Heft 3–4, 1923, pp. 134–43.

FIG.
4.—*Phacops (Acastella) macrocentrus* subgen. et sp. nov. Pygidium. × 4. Upper Ludlow. Prior's Frome, near Woolhope. Mr. C. I. Gardiner's Collection.
4*a*.—Ditto. Side view of same specimen. × 4.
5.—*Acidaspis (Leonaspis)* sp. Impression of free cheek. × 8. Lower Ludlow, near Wooton Farm, 1 mile N.E. of Mordiford, near Woolhope. Mr. C. I. Gardiner's Collection.

On Marine Triassic Fossils from the Malayan Provinces of Kedah and Perak.

By R. Bullen Newton, I.S.O., F.G.S., Geological Department British Museum (retired).

(PLATE III.)

THE following notice of some fossils recently collected in the northern Malayan Province of Kedah, has been prepared at the instance of Mr. J. B. Scrivenor, M.A., F.G.S., Government Geologist of the Federated Malay States. A study of this new material has rendered necessary the revision of a published paper by the late Professor T. Rupert Jones, F.R.S., dealing with some supposed Phyllopod valves from the same country which were obtained from similarly constituted rocks as those at Kedah, although occurring at a more southern locality in the adjacent province of Perak.

The Kedah specimens mainly consist of a number of small Pelecypod valves which, on account of their association with Ammonoid remains and fragmentary stems probably belonging to a Crinoidal organism, suggest an undoubtedly marine origin. For this discovery we are indebted to Mr. E. S. Willbourn, B.A., F.G.S., the Assistant-Geologist of the Federated Malay States who obtained them from near Kuala Nerang (Field No. 5351), and Kampong Kuala (Field No. 5354), the latter locality being 13 miles east of the former, and 4 miles from the Siamese frontier. According to Mr. Willbourn's manuscript statement the fossils from both these localities were found in " black shales interbedded with black quartzite " ; whilst a further remark indicates that " outcrops of quartzite-conglomerate occur a few hundred yards from the last-mentioned fossil-locality (viz. Kuala Nerang), which we regard as basal members of the quartzite and shale series."

The sculpture characters of the shells are generally well preserved, although it is noticeable that actual test-structure is not present on any of the valves, while no calcareous constituents are discernible in the dark shales which form their matrix.

The more interesting of the Pelecypod valves are of abundant occurrence, very young forms often surrounding those of older age. The latter are displayed as delicate and flattened impressions on the surface of the matrix, and therefore represent valves of only slight convexity, while the immature forms chiefly illustrate the umbonal or prodissoconchal region where a more distinctly convex character is present.

From a study of their structural features, which are more or less of a uniform type, the valves appear to indicate that they belonged to one individual organism, although the presence among them of one or two other Pelecypod valves, exhibiting different characteristics, should be mentioned.

It is important to bear in mind the marine facies of this fauna, more especially in connexion with the Pelecypod valves, as very similar shell-remains were discovered some years since by Mr. Scrivenor in a non-calcareous dark shale of the same country (Pukus Semanggol, Perak), which were described and figured by the late Professor T. Rupert Jones,[1] as the carapace valves of a Phyllopodous Crustacean, under the appellation of *Estheriella radiata* (Salinas) var. *multilineata*, Jones, the Salinas species having originally come from the Trias (Carnian) formation of the Island of Sicily. As is generally recognized, Phyllopod life is restricted to freshwater marshes, and to pools of brackish and sometimes stagnant waters, being totally unknown as frequenting the open sea. Therefore, when found in geological deposits, such Crustacean relics would imply that freshwater or lacustrine conditions must have prevailed during the period of sedimentation.

No other fossils had been found with those described by Rupert Jones, so that he was without confirmatory evidence as to their marine or freshwater origin, although he must have clearly favoured the latter view, because of acknowledging their phyllopod characters and their supposed relationship to *Estheria radiata* as figured by Salinas.[2] He, moreover, overlooked some points of structure in the Malay fossils which were of Molluscan interest and unconnected with Crustacean morphology. Hence, he determined the valves as *Estheriella* of Weiss,[3] a genus chiefly differing from the true *Estheria* by its possession of a radially striated ornamentation, and known only to have existed in Triassic times. A more critical examination of the valves in question has now been undertaken, so that with the aid of the actual type-material for comparison, kindly sent me by Mr. Scrivenor from his geological collections located in the Federated Malay States, it is hoped that a final pronouncement on the zoological position of these interesting fossils may be satisfactorily explained.

Concerning the probable geological horizon of the fossils referred to in this paper, it can only be again emphasized that as the principal Pelecypod valves indicate affinities with Merian's *Posidonomya moussoni*, a species characteristic of the Muschelkalk or Middle

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[1] T. R. Jones, "Note on a Triassic *Estheriella* from the Malay Peninsula": Geol. Mag., 1905, pp. 50–2, pl. 2.

[2] E. Salinas, Sulle Esterie del Trias di Sicilia: *Mus. Geol. Min. R. Univ. Palermo*, 1897, pp. 1–12, pl. 1.

[3] E. Weiss, Ueber Estherien im Buntsandstein von Durrenberg in Sachsen: *Zeitsch. Deutsch. Geol. Ges.*, 1875, vol. 27, pp. 710–12.

Trias, so it is thought that a similar age may be assigned to the shaley-clay deposits of Kedah and Perak which have yielded this small and interesting fauna. Certainly, the evidence seems to be in favour of the beds in question being of rather older Triassic age than the so-called "Myophorian Sandstone" from near Kuala Lipis, which was described some years ago.[1]

For clerical assistance in the preparation of this report, I have to thank Mr. H. B. Rowbotham, of the Geological Department, British Museum.

MOLLUSCA.

CEPHALOPODA.

Indeterminable Ammonoids. (Plate III, Figs. 1, 2.)

Remarks.—This small collection of Triassic fossils contains two Ammonoids which, although useless for identification purposes, claim an interest in support of the marine origin of the deposits in which they are found.

Ammonites indet. (A).—Fig. 1 (× 2) represents a magnified lateral aspect of a small fragmentary specimen in two pieces consisting of white, mineralized, slightly excavated impressions on a dark grey matrix, the internal surfaces of which, with the aid of a wax squeeze, are seen to possess rather thick and rounded costations extending from the umbilical region to the periphery, with a tendency to bifurcation about midway. A sulcus is also observable, emanating from the umbilical centre. Such features appear to suggest that this fossil may probably be referred to a form of the Arcestidae, which is a characteristic family of Triassic times.

Dimensions.—18 by 15 mm.

Occurrence.—Numerous young forms of *Halobia*-like valves are in close association with this specimen.

Ammonites indet. (B).—Fig. 2 (× 3) shows a magnified lateral surface of a very young Ammonite-impression possessing distant, straight, radial ribs, which appear to exhibit obscure evidence of nodulations. This fossil bears some resemblance to the genus *Balatonites*, a member of the *Ceratitidae*, which is well known in rocks of Trias age.

Diameter.—7 mm.

Occurrence.—This Ammonoid is surrounded by immature valves of *Halobia*-like shells.

Locality.—Near Kuala Nerang (Field No. 5351).

PELECYPODA.

Halobia cf. moussoni, Merian *em.* Stoppani. (Plate III, Figs. 3–10.)

Posidonomya moussoni Merian, in Escher's *Geol. Bemerkungen Vorarlberg*, etc., 1853, p. 93, pl. v, figs. 46–8; Stoppani, *Pal. Lombarde-Pétref. d'Esino*, 1858, p. 94, pl. xix, figs. 10, 11, *non* figs. 7–9.

Daonella moussoni, Mojsisovics: *Abhandl. K.K. Geol. Reichs* (Triadischen *Daonella* und *Halobia*), 1874, vol. 7, pt. 2, p. 9, pl. iii, figs. 18, 19.

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[1] R. B. Newton: *Proc. Mal. Soc. London*, 1900, vol. iv, p. 130, pl. xii.

Halobia moussoni Lepsius: *Das Westliche Süd-Tirol*, 1878, p. 356, pl. ii, fig. 1; Tommasi, A., *La Fauna del Calcare Conchigliare (Muschelkalk) di Lombardia (Pavia)*, 1894, p. 99.

(*Daonella*) *Halobia moussoni* E. Philippi: *Zeitsch. Deutsch. Geol. Ges.*, 1895, vol. xxxxvii, p. 703.

Estheriella radiata (Salinas) var. *multilineata* T. R. Jones: GEOL. MAG., 1905, pp. 49–52, pl. ii.

Daonella moussoni Arthaber: Frech's *Lethaea Geognostica (Trias)*, 1905, vol. i, pl. xxxv, fig. 16; E. Kittl: *Halobiidae und Monotidae der Trias*: Result Wissensch. Erforsch. Balatonsees (Wien), 1912, part iv, p. 35, pl. i, figs. 20–3.

Remarks. --The original characters of the Malay valves drawn up by Rupert Jones, as representing the Phyllopodous organism *Estheriella radiata* (Salinas) var. *multilineata* Jones, may very well be reproduced on this occasion as they apply in general details to Stoppani's emended description of *Posidonomya moussoni* of Merian from the Middle Trias of Lombardy, etc., to which the Malay specimens are very closely related, and which appear to be chiefly distinguishable from that species on account of their much smaller size, the original figures of Merian representing a length of shell varying from 25–45, and a height varying from 18–36 mm., whereas the Malay valves exhibit a maximum length of only 13 mm., and a height of 10 mm. This description is as follows:—

"The valves are broadly subovate, nearly semicircular, short, and broad, or oval-oblong with rounded ends. The anterior extremity has the bolder curvature. The dorsal border is nearly straight; ventral border boldly curved. The umbo is towards the anterior end of the dorsal border at about one-third of the length of the valve. Behind the umbo the border gently slopes to the postero-dorsal angle, and has a distinct, but narrow, marginal fold." Further details refer to the presence of "many concentric parallel ribs" crossed by "twenty-four and more delicate, close-set, parallel, linear furrows, radiating from the umbo to the ventral edge of the valve".

Dimensions.—Adult valves:—Length=13 mm., height=10 mm.

In connexion with sculpture details, it should be pointed out that the radial striations or riblets are of slender character, and very numerous, probably numbering about 60, as mentioned by Stoppani. They are of two strengths, comprising those that are very fine and closest together, and those that are distant and more prominent, the latter equidistantly arranged and narrowly sulcated, thus enclosing the others, which together form a system of flat-topped costae, being probably those that were referred to by Jones as numbering "24 and more".

Stoppani has emphasized the importance of these depressed costal summits as a character separating *P. moussoni*, Wissmann's *Halobia lommeli* (Munster's: Beitrage Petref.-Kunde, 1841, part 4, pp. 22, 23, pl. 16, fig. 11), a species in which the ribs are not only convex above, but distinctly grouped in series as well, and although occurring on the same geological horizon, it enjoys a wider geographical range, its distribution extending from European to Far Eastern countries. This costal structure is illustrated by Fig. 6 of the present plate, which is a copy of fig. 4 of Jones's original plate.

The occurrence of these valves in the Malay Shales is thus referred to in the original account :—" Numerous specimens (having the general aspect of *Estheria*) lie on the bed-planes of a bluish, slightly micaceous, non-calcareous shale from the " Shale and Sandstone Series " of the Federated Malay States. The valves lie flatwise in the strata, either singly or in still connected pairs ; and are not so much compressed but that they show the concavity of the insides, and the convexity and special features of the outsides. There are many examples of valves in different stages of growth, but a striking similarity of character indicates that all belong to one species. The shell itself is absent, but hollow moulds of one valve and solid casts of the other supply material for defining its character. No other organisms have been recognized in the shale."

Horizon and Distribution.—The true *Halobia moussoni* (Merian) is restricted to the Middle Trias or Muschelkalk deposits of Austrian-Italy (chiefly Lombardy), having been found in the *Ceratites trinodosus* zone, as also in the Varenna limestone (Regoledo), and in the Esino beds. Its occurrence in other and more distant regions appears to be unknown. The affinities of the Malay valves with the European species would, therefore, suggest that the deposits containing them may be referred to that part of the Middle Trias which belong to the Anisian (=Virglorian or Dinarian) and Ladinian groups of that formation.

Locality.—Pukus Semanggol, Larut, Perak. (12 miles from Taiping.)

In reviewing afresh the structural details of the Jonesian *Estheriella* from the Malay Peninsula, it should be mentioned that in general form and sculpture it may be more correctly recognized as being closely related to *Posidonomya moussoni* of Merian,[1] from Middle Trias deposits of Lombardy (near Varenna, etc.), a pelecypod of the family Halobiidae. The characters of *P. moussoni* were insufficiently defined at the time of original publication although accompanied by some good figures. A few years later, however, A. Stoppani[2] rendered a fuller account of this shell in his *Monographie des Acéphales . . . Pétrifications d'Ésino*, mentioning an important feature of the hinge region which he thus referred to :—" Charnière linéaire, avec une fossette linéaire, très-longue et très-étroite pour le ligament." This character is fortunately well displayed in the Malayan valves, and is of considerable Pelecypod interest. Credit is due, of course, to Rupert Jones for pointing out the presence of the " narrow marginal fold ", although he apparently never realized its importance in connexion with Pelecypod structure, nor did he remark on its value as a Phyllopod character.

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[1] In Escher's Geol. Bemerk. Vorarlberg, etc., 1853, p. 93, pl. v, figs. 46–8.

[2] Palèontologie Lombarde—Pètref—d'Ésino, 1858, p. 94, pl. xix, figs. 10, 11.

Such a structure, known only among certain of the edentulous Pelecypod Mollusca, primarily the Halobiidae, was evidently the receptacle for a linear, internal ligament, or resilium,[1] by which the opening of the valves was governed, their closing being effected by the contraction of the internal adductor muscles. Phyllopod valves, like *Estheria* or *Estheriella*, although united by a straight toothless margin approaching some Pelecypods, are without any ligament, their operating functions being controlled by the action of a transverse adductor muscle. Jones compared the Malay valves with specimens from the Sicilian Trias, described by Salinas [2] as *Estheria radiata*, and on account of the presence of radial striations which more or less covered the surface, he regarded the fossils in question as belonging to *Estheriella* of Weiss,[3] a genus first described from the Bunter Sandstone of Durrenberg in Saxony, recognizing them under the Salinas species, as *Estheriella radiata* being further induced to add the new varietal name of *multilineata* on account of the existence of certain details of sculpture which were not expressed in the Sicilian species. It is the presence of this elongate ligamental character forming the postero-dorsal margin which suggests that the Merian species belongs to Bronn's genus *Halobia* rather than to *Daonella* of Mojsisovics with which *H. moussoni* has been usually associated.

For fairly late information on this group of Pelecypod shells, we are indebted to Dr. Ernst Kittl.[4] His monograph dealing with the Pelecypod families of the Halobiidae and Monotidae occurring in the Trias formation was published in 1912, the Halobiidae embracing the genera *Posidonia*, *Halobia*, and *Daonella*. In this work doubt is expressed as to the accuracy of determination affecting certain fossils referred to the genus *Estheria*, one of the Phyllopod Crustaceans, the author being of opinion that many young Pelecypods have been mistaken for that genus. True Estherian valves differ from Pelecypod structures in having a horny texture besides presenting a reticulate ornamentation of microscopical dimensions between the concentric ridges; moreover, *Estheria* is indicative of a fresh or brackish water origin. Among examples illustrative of these views, Kittl mentions certain forms of *Estheria* described by Salinas from the Sicilian Trias, which in his opinion really represent the embryonic or young conditions of the marine genus *Halobia*, and not *Estheria*. This conclusion is of interest since it helps to explain why some fossil species of the so-called *Estheria* are often recorded as being associated with a marine fauna, whereas deposits containing undoubted Phyllopod valves would imply freshwater conditions of sedimentation.

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[1] The more distinctive term "resilium" was introduced by Professor W. H. Dall to replace that hitherto known as "internal ligament". (*Trans. Wagner. Free Inst. Sci. Philadelphia*—Tertiary Fauna Florida, 1895, vol. iii, pt. iii, p. 498.)

[2] *Sulla Esterie del Trias di Sicilia*, 1897 (Palermo), pp. 1–12, pl. i.

[3] *Zeitsch. Deutsch. Geol. Ges.*, 1875, vol. xxvii, pp. 710–12. In this paper Weiss selected two of Giebel's species in illustration of *Estheriella*, viz. *Posidonomya nodocostata* and *P. wengensis*.

[4] *Result. Wiss. Erforsch. Balatonsees*—Palaeontology, vol. ii, pt. iv, 1912.

In September, 1923, Mr. Willbourn collected some more examples of the Jonesian "*Estheriella*" from what is regarded as the original locality, although rather differently expressed as :—near Gunong Semanggol, at the road-cutting, 12 miles from Taiping. They were dispatched to the British Museum for my examination, but no complete valves indicative of adult age were observable, and only those of smaller size exhibiting prodissoconchal or umbonal regions with strong concentric plications crossed by more or less feeble, radial striations, were to be seen on the clay-matrix. In these earlier stages of development, the postero-dorsal "marginal fold" is apparently not developed.

Some further remains of these valves showing a close relationship with *H. moussoni* may be identified among Mr. Willbourn's latest specimens from Kedah (Kuala Nerang), bearing the field-number 5351, some of which are represented on the plate of illustrations. These include a well-preserved matrix-impression (Fig. 7) of a right valve displaying external characters which include complete and uninterrupted marginal lines, whilst the postero-dorsal region is furnished with a fairly well-developed convexo-linear process indicative of a former resilium chamber.

The surface generally exhibits a delicate and well accentuated radial and concentrically ridged sculpture. The equidistant radial sulci dividing the principal costae with their flattened summits, are well defined, together with the subsidiary riblets which are finer and more numerous as they descend from the prodissoconchal region, but becoming less obvious on the more ventral portions of the valve.

Dimensions.—Height=9 mm., length=10 mm.

An external view of a smaller right valve probably belonging to this species, is also represented (Fig. 8). The subquadrate contour and sculpture lines are very similar, although the details of the hinge region are somewhat obscured, and there are only feeble indications of a marginal fold.

Dimensions.—Height=6 mm., length=9 mm.

There is a still smaller right valve of more oval shape (Fig. 9), where the equidistant primary striations are seen to be marked by well-impressed sulci, and so resemble structures originally described by Rupert Jones. Slight evidence of the marginal fold of the hinge region is also present.

Dimensions.—Height=5 mm., length=6 mm.

Another specimen represented (Fig. 10), although only in a fragmentary condition, shows the wide and flat-topped ribs divided by narrow radial sulci, the ribs sometimes assuming an appearance of bifurcation, whilst the concentric plications are clearly defined. These sculpture details strongly resemble Dr. Mansuy's *Daonella cf. indica* from the Muschelkalk horizon of Tonkin, Indo-China, a form, however, I would consider more closely related to *H. moussoni*

(Mém. Serv. Géol. Indochine, 1921, vol. 8, fasc. 1, p. 34, pl. 3, fig. 13) than to *D. indica.*

Dimensions of fragment.—Height=8 mm., length=9 mm.

Halobia-like valves. (Plate III, Figs. 11–13.)

Young forms of *Halobia*-like valves are largely distributed over the matrix surfaces from both the Kedah (Fig. 11) and Perak (Figs. 12, 13) Provinces of Malaya. They appear to represent prodissoconchal regions having fairly elevated summits, as well as being furnished with strong concentric plications, and in some cases obscure radial striations. On account of their immature development, there is no trace of the "marginal fold" on the horizontal hinge area. I am inclined to regard all these remains as belonging to a form closely related to *H. moussoni.*

Dimensions.—Largest valve on slab—Height=3 mm. Length=3½ mm. } Fig. 11.

Locality.—Near Kuala Nerang. (Field No. 5351.)

Dimensions.—Largest valve on slab—Height=4 mm. Length=5 mm. } Fig. 12.

Dimensions.—Largest valve on slab—Height=3 mm. Length=4 mm. } Fig. 13.

Locality.—Kampong Kuala. (Field No. 5354.)

Halobia malayensis, sp. nov. (Plate III, Fig. 14.)

Description.—Valve perpendicularly oblong, height in excess of the length, slightly elevated at the summit, but otherwise depressed; ornamentation consisting of prominent concentric furrows and plications which are coarsest in the umbonal region, but which later become finer and more crowded as they approach the ventral margin; distant, obscure radial costae are also present; umbone antero-median; hinge line short, horizontal, furnished with a postero-dorsal resilium process which is separated by a narrow sulcus from the upper margin of the valve.

Dimensions.—Height=10 mm., length=9 mm.

Remarks.—This fossil may be distinguished from *H. moussoni* on account of its oblong contour, the possession of less conspicuous radial costae, and the presence of finer and more numerous concentric lineations, extending to the ventral margin after leaving the stronger concentrics of the umbonal region. The resilium organ of the hinge area supplies one of the chief characters in favour of the fossil belonging to the genus *Halobia* rather than to *Daonella.* Only one example of this form is in the collection.

Locality.—Near Kuala Nerang. (Field No. 5351.)

ECHINODERMATA.

Crinoidal Stems. (Plate III, Fig. 15.)

Remarks.—Fragmentary bodies resembling crinoidal-stems are observable in some of the clay-matrix of this collection.

The principal specimen which is figured (Fig. 15) shows a hollow impression of a small stem possessing almost parallel sides with distinctly marked, segmented ossicle-cavities, which, according to other surrounding relics of the same organism, are more or less elliptical in section. The articulating surfaces appear to have lost all radial ornamentation, whilst the exposed margins of the segments present no sutural serrations, all such structures having been probably obliterated by mineralization. Further specimens from the same deposits, may in the future yield more satisfactory material which would lead to a fuller determination than is now offered, of this interesting fossil. It may be stated that Crinoidal stem-fragments are quite well-known in Triassic rocks of European and Eastern countries.

Dimensions.—Length of stem=18 mm.
Diameter =1·5 mm.

Locality.—Kampong Kuala. (Field No. 5354.)

Note.—The fossils here described have been presented to the Geological Department of the British Museum by Mr. J. B. Scrivenor, including the original types studied by the late Professor T. R. Jones, which formed a special donation after this paper had gone to press.

EXPLANATION OF PLATE III.

AMMONITES indet. (A).

Locality.—Near Kuala Nerang, Kedah. (Field No. 5351).

FIG.

1.—A magnified lateral aspect of a fragmentary specimen showing rounded, bifurcating costae and a sulcus leading from the umbilicus to the periphery. Probably belonging to the Arcestidae. Photographed from a wax squeeze. × 2.

AMMONITES indet. (B).

2.—A magnified lateral view of a young Ammonite-impression with straight and distant, probably nodulated radial ribs, somewhat resembling *Balatonites*. × 3.

HALOBIA CF. MOUSSONI (Merian).

Locality.—Pukus Semanggol, Larut, Perak (12 miles from Taiping).

3.—External view of a left valve showing the anterior position of the umbo and the postero-dorsal marginal fold, which originally held the resilium or internal ligament. Reproduced from plate 2, fig. 1, of the original paper by Jones. × 3.

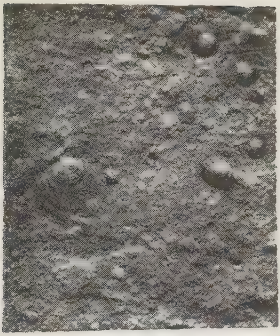
4.—Inner view of a pair of extended valves exhibiting the postero-dorsal furrow-like receptacles for the resilium. Reproduced from plate 2, fig. 2 of the original paper by Jones. × 3.

5.—Outer aspect of a fragmentary right valve with the convex plications crossed by well-impressed radial striations. Reproduced from plate 2, fig. 3, of the original paper by Jones. × 3/2.

6.—Magnified structure of valve showing the distant primary radial riblets with a more feeble subsidiary series within. Reproduced from plate 2, fig. 4 of the original paper by Jones. × 8.

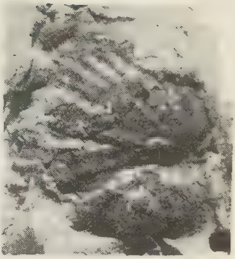
Locality.—Near Kuala Nerang, Kedah. (Field No. 5351.)

7.—External view of a right valve showing complete contour lines, clearly expressed details of sculpture and evidence of the postero-dorsal "marginal fold". × 3.

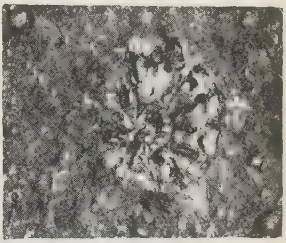


11 × 3

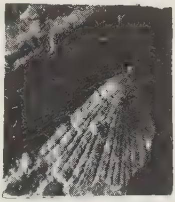
14 × 2



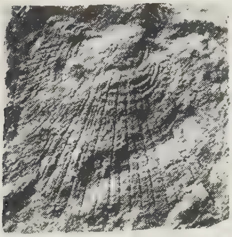
1 × 2



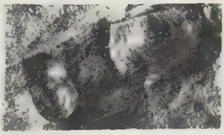
2 × 2



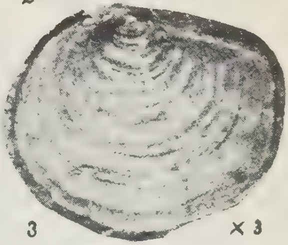
10 × 2



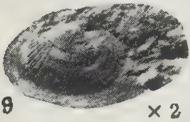
7 × 3



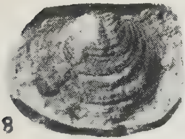
12 × 2



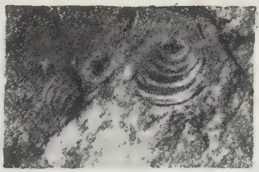
3 × 3



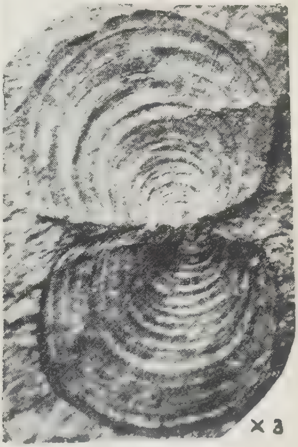
9 × 2



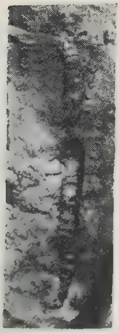
8 × 2



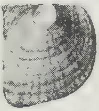
13 × 3



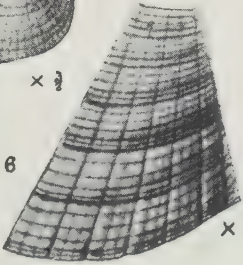
4 × 3



15 × 2



5 × 3



6 × 8

Marine Triassic Fossils from the Malay States.

[To face p. 84.

FIG.

8.—Showing external features of a smaller right valve, with obscure indications of the "marginal fold". × 2.

9.—An outer view of a still smaller right valve, rather more transversely oval than usual, with well-impressed equidistant sulci in the radial arrangement. Evidence of the "marginal fold" is present. × 2.

10.—Fragment of another valve showing the principal and intermittent ribs, the latter more or less bifurcating in their descent to the ventral margin. Concentric plications chiefly defined around the region of the prodissoconch. × 2.

HALOBIA-LIKE VALVES.

Locality.—Near Kuala Nerang. (Field No. 5351.)

11.—A small slab of matrix displaying young forms of *Halobia*, showing prodissoconchal regions with both concentric and radial markings. × 3.

Locality.—Kampong Kuala. (Field No. 5354.)

12.—A pair of valves showing interiors associated on the same matrix with a larger valve exhibiting external sculpture. × 2.

13.—A small slab of matrix with two valves of different sizes, the larger one showing the usual equidistant concentric plications while the other represents the internal surface of a valve. × 3.

HALOBIA MALAYENSIS, sp. nov.

Locality.—Near Kuala Nerang. (Field No. 5351.)

14.—An external aspect of a left valve showing oblong shape, short hinge line furnished with a resilium process, and details of sculpture. × 2.

CRINOIDAL STEM.

Locality.—Kampong Kuala. (Field No. 5354.)

15.—A supposed Crinoidal stem of small size in the condition of a hollow impression, although preserving a united series of ossicles in its central course which have been lost since the figure was prepared. Nearly equal segments are observed throughout its axis. × 2.

Notes upon the small species of *Chonetes* found in the Lower Carboniferous around Bristol.

By STANLEY SMITH, M.A., D.Sc.

SMALL species of *Chonetes* are frequently found crowding the limestones in the lower part of the Avonian Succession round Bristol and in the Mendips. Of these *Ch.* cf. *hardrensis* (Phill.) is the most persistently abundant throughout its range Km–Z1, but the two other species, *Ch. failandensis* sp. nov. and *Ch. stoddarti*, Vaughan, here mentioned, occur in equally large numbers at particular levels within that horizon. The following notes are the outcome of the study of the material recently collected by Professor S. H. Reynolds, and myself, at St. Monica's Home of Rest, Westbury-on-Trym, but this has been considerably supplemented by specimens obtained from other localities in the district.

Chonetes cf. *hardrensis* (Phillips),[1] 1841, Figs. and Descr. Palaeoz. Foss. Cornwall, etc., p. 138, pl. lviii, fig. 104*a–d*, and pl. lx, fig. 104.*

The forms connoted by this name are concavo-convex, but the ventral valve is not strongly inflated and the dorsal valve is nearly flat; the proportion of the height to the length is approximately 2 : 3, the average size of the specimens being 7 mm. by 11 mm., although larger ones are not uncommon. The costae are fine, there being 5 to 6 in 1 mm. near the margin; they persist without loss of definition to the hinge. The primary costae bifurcate, or new ones are interpolated about 3 mm. from the umbo.

These Tournasian forms seem to differ from those of the same species (?) that I have collected myself from the Acre Limestone-Viséan D2—in Northumberland, and that I have had sent to me by Mr. Robert Dunlop from an equivalent horizon in Scotland—(approx. Hurlet, Limestone, Woodmill, Dunfermline) in the dorsal valve being less concave.[2]

Chonetes failandensis, sp. nov. = *Ch.* cf. *crassistria* (M'Coy), Vaughan, 1905, *Q.J.G.S.*, p. 294. Figured by Vaughan, loc. cit., pl. xxvi, fig. 2.

In shape and size, and in the bifurcation of the costae *Ch. failandensis* agrees with *Ch.* cf. *hardrensis*, but it differs from that species in the coarseness of the costae and in the fact that these become more or less obliterated near the hinge. Moreover, the dorsal valve is flat.

Average size of the shell 7 mm. by 11 mm., but larger ones not infrequent. Number of costae per mm. near the margin is 3 to 4, bifurcation of costae approximately 3 mm. from umbo. Shell finely crenulated by transverse striae, but this character can only be seen in well-preserved specimens.

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[1] This is the most satisfactory name for present use, but it is possible that a thorough revision of the group may necessitate some restriction of the name. The species requires redefining upon the type, or failing this upon a neotype. The original description by Phillips is inadequate for present-day purposes, and Davidson (*Pal. Soc.*, 1857, p. 186) appears to interpret the species too widely. The syntypes of *Orthis hardrensis* includes specimens from the Devonian and the Carboniferous. The former is (or are) from the Meadfoot Sands (Lower Devonian) of Berry Pomeroy, S. Devonshire (pl. lx, fig. 104*), and the latter were from [the Lower Culm] Westleigh, N. Devonshire (pl. lviii, fig. 104*a*), and [the Yoredale Series] Hardraw, Yorkshire (pl. lviii, figs. 104*b–c*). Phillips named the species after the last-mentioned locality, which, judging from the figures, supplied the more perfect specimens. It seems reasonable to select the Yorkshire form as the lectotype. It is very doubtful, however, whether the original types are now in existence.

[2] See note by Mr. L. B. Smyth, Geol. Mag., Vol. LIX, 1922, p. 23, "On some New Species from the Lower Carboniferous of Ballycastle, co. Antrim," pp. 21–4, Pl. III.

Vaughan compared the form with *Ch. crassistria* (M'Coy),[1] but that species, which closely approaches, if it is not actually identical with, *Ch. buchiana* de Kon., is larger, much more gibbose, and has simple strong ribs.[2]

Vaughan states, 1905, op. cit. "*Chonetes* cf. *crassistria* is employed in the text, to cover small Chonetes with coarse ribbing which fork on the *hardrensis*-plan. *There is a complete transition between these forms and Chonetes 'buchiana' Dav.* The ribs in a typical example of *Chonetes* cf. *crassistria* often exhibit the transverse, erect scales which characterize *Ch.* cf. *buchiana*; *and, by a diminution in forking, Ch. cf. crassistria passes imperceptibly into Ch. cf. buchiana.*" With the remarks here put into italics I disagree. Except sporadically, and then near the margin, the costae of *Ch.* cf. *buchiana* do not bifurcate. These statements of Vaughan are explained, however, by the fact that at Failand *Ch. stoddarti* (=*Ch.* cf. *buchiana*) occurs associated with *Ch. failandensis* and the less well-preserved specimens could readily lead to Vaughan's conclusion.

At Failand and in the foundations of St. Monica's, *Ch. failandensis* is found crowding the same type of light-coloured flaggy limestone near the top of K2.

I gave the species the name of the locality from which the specimen figured by Vaughan was obtained, but I take as the holotype a specimen from St. Monica's, Westbury.[3]

Chonetes stoddarti, Vaughan, 1911, *Q.J.G.S.*, p. 381 (= *Ch.* cf. *buchiana* de Kon., Vaughan, 1905, *Q.J.G.S.*, p. 294. Figured, Davidson, 1860, Pal. Soc., pl. lv, figs. 12, 12*a*, and 12*b*.

The shell is smaller, thicker, and less transverse than *Ch.* cf. *hardrensis* and *Ch. failandensis*. The ventral valve is much more inflated than in those species and the dorsal valve is distinctly concave. Sides of shell developed into slight wings. Usual size 5 mm. by 7 mm. to 7 mm. by 9 mm., thickness measurement through the valves about 2 mm. The costae are stout and are typically simple, bifurcation may occur, but this is near the margin of the shell, and then usually in one or two costae only. Number of costae (measured near the margin) in a millimetre, 2. At the wings the costae are obliterated. The shell is concentrically striated, and the costae carry the bases of numerous spines.

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[1] *Syn. Char. Carb. Limest. Foss. Ireland*, 1844, p. 119, pl. xx, fig. 10 (*Leptaena crassistria*). Concerning this figure M'Coy remarks (*Brit. Pal. Foss.*, p. 454) "In my original figure there seem, unfortunately, a few ridges too many, and owing to this erroneous crowding, their curious simplicity is not sufficiently apparent."

[2] These remarks are made after examining a specimen from Derbyshire in the Sedgwick Museum, Cambridge, named by M'Coy, but not the type.

[3] The type has been placed in the British Museum (B 44901). Paratypes have also been deposited in the British Museum (Ca 7389) and in the Coll. Univ. of Bristol.

Vaughan, 1911, op. cit., in proposing a new name for this form, remarks: "The resemblance to *Ch. buchiana* de Kon. of the upper Visean (D) consists solely in the similarity of ribbing; the D species is transverse, with a broad rolled beak. It is necessary, therefore, to separate this form from *Chonetes buchiana* under a new specific name; I propose *Ch. stoddarti* in commemoration of the late W. W. Stoddart, of Bristol, who collected the specimens studied by Davidson."

Ch. stoddarti has hitherto only been recorded from K1 (see Vaughan, op. cit.), and at Westbury we only found it at one horizon in that sub-zone. But, as previously pointed out, it is present along with *Ch. failandensis* in upper K2 beds from which the latter was first obtained.

In the collection of Bristol University there are specimens of a Chonetes from K1, Maesbury, which agrees with *Ch. stoddarti* in having simple costae and in being markedly crenulate, but which differs from it in being larger (7 mm. by 13 mm.), flatter (though inflated as compared with *Ch.* cf. *hardrensis*, and *Ch. failandensis*) and more transverse, and having much finer ribbing (4 costae to 1 m.).

These notes omit details concerning the internal characters of the shells, but this is unavoidable since the material available does not display the interior of the valves sufficiently well to allow any comparisons to be made. A serious attempt at revision of the genus cannot afford to ignore the muscle impressions and other internal characters.

Chonetes cf. *hardrensis* and *Ch. failandensis* perpetuate the same type of costation (fine costae which are increased in number by bifurcation and interpolation) observed in the Silurian species *Ch. striatella* (Dalman), Davidson.

The same type of costation also obtains in the large Carboniferous species, *Ch. papilionacea* (Phillips) and *Ch. comoides* (Sowerby), but carried to a much further degree. On the other hand, *Chonetes buchiana* and *Ch. stoddarti*, with their strong simple costae, which rarely bifurcate, seem to have a representative in the Devonian species *Ch ? minuta* (Goldfuss) Davidson, but I have only Davidson's description and figure to warrant this statement (Davidson, 1864–5, Devonian Brachipoda, p. 96, pl. xix, figs. 10–12).

These facts may be interpreted as indicating genetic relationships or they may merely instance homeomorphous developments in distinct lineages; in any case they suggest fruitful lines of inquiry.

REVIEWS.

Les Minerais de Fer Oolithique de France. By L. Cayeux. Fasc. II. Minerais de Fer Secondaires, pp. 1051, with 35 plates. Paris: Imprimerie Nationale, 1922.

THE second part of this great work, long awaited with eagerness, as it contains the author's account of the iron ores of Lorraine, has now appeared, and proves to be a gigantic volume of over 1,000 quarto pages with thirty-five beautiful plates. Incidentally we may remark that it is rather curious to find a grammatical mistake in the title of a work of this character. Literally translated, it means " The ores of oolitic iron of France ", instead of " The oolitic iron ores of France ", which is the obvious intention of the author. A large part of it is, of course, taken up by stratigraphical details of the Mesozoic iron ores of France in general, which range from the Lias to the Cretaceous. The reviewer cannot pretend to have read all this, but the more general sections dealing specially with the genesis of the ores provide quite sufficient material for much thought. Here attention will be confined to the ores of Lorraine, which are of by far the greatest commercial importance, yielding as they do now the second largest output of iron ore in the world.

It may be noted in passing that French geologists still continue to assign this formation to the Upper Lias, while most German geologists consider them to be of Middle Jurassic (Dogger) age. At any rate they are roughly homotaxial with the iron ores of Northamptonshire rather than with those of Cleveland. However, they differ from both these English examples in the predominance of haematite, often true red haematite. It is worth mentioning that M. Cayeux, like so many other authors, often speaks of " brown haematite ", a term which in scientific writings is open to objection, since it encourages commercial and technical writers in the misuse of mineralogical terms.

The point of greatest interest in these volumes is naturally the very complete and elaborate discussion of the origin of oolitic ores in general: this has long been one of the mysteries of sedimentary petrology, and the author's painstaking and detailed researches extending over so many years have gone a long way towards solving it. For many years the idea prevailed, at any rate in this country, that oolitic iron ores were derived from oolitic limestones by metasomatic replacement of calcium carbonate by iron compounds derived from percolating solutions. For long the present reviewer strongly held this opinion, but a careful study of the literature and much original investigation by microscopic and chemical methods has convinced him that in most cases at any rate this view is untenable, especially as regards the British Jurassic ores. It is not easy, however, to provide an alternative explanation, and it seems clear that the same theory will not fit all cases. For this reason the careful and detailed work of Professor Cayeux is specially welcome.

It will be well to quote first some of his conclusions as to the genesis of the Lorraine ores, which may be summarized as follows. The formation of the oolitic ores took place during a period of general disturbance, with great instability of conditions both dynamical and biological, and the influence of currents is strongly marked, as shown by wash-outs and cross-bedding and the occasional influx of considerable quantities of quartz sand, as well as by the frequency in the ores of pebbles having the same composition as the matrix: also the ores must have solidified very soon after their final deposition. It is believed that all the oolite grains have undergone more or less transport; their formation and mineral evolution was not effected in situ, but in some other locality, probably not far distant; the actual source of the iron must have been in some land area, whose position has not been identified. Further it is demonstrated that no oolith has undergone any further evolution after it had once arrived in its present situation, although the matrix (cement) has undergone a succession of changes.

The order of succession of the different mineralogical stages in a given oolith, or in the cement, is usually as follows: calcite, siderite, chlorite, haematite. Many ooliths have passed through all of these stages, but not rarely the two middle stages are omitted, the calcite passing straight to haematite. In certain places, however, a reversal appears to have occurred; thus at Godbrange both haematite and chlorite have passed to siderite. In the cement, chlorite may also be developed from argillaceous matter (clay).

Very frequently the nucleus of an oolith is a broken fragment of an oolith of the same or a different stage of development. (This is also the case in many British examples.) Organic remains are numerous, and have often remained as calcite, although they may also be more or less converted into iron oxides or chlorite. No siliceous organic remains have been identified.

It has not yet been found possible to work out any chemical or physical explanation of the succession of mineralogical changes which are clearly demonstrated for both ooliths and cement; in particular the general conversion of chalybite into a green silicate of the chlorite group is decidedly mysterious. On the constitution and characters of this green silicate a good deal has been written. However, it appears to be a matter of little importance whether it is called chlorite as in the work of Cayeux, chamosite or thuringite by various German authors. The admirable memoir by Hayes on the Wabana ores of Newfoundland prefers the name chamosite, and in a general way there is a very considerable resemblance to glauconite. This green compound, whatever it is called, is also very abundant in and characteristic of the Middle Lias ores of Cleveland and the Banbury district and of the less weathered portions of the Northamptonshire ironstones. In the Frodingham ore of North Lincolnshire a good deal of green material occurs, largely as a thin coating on the surface of calcareous shells, which are often of very large size.

The last-named fact is one of much significance in the study of the genesis of such ores. When large and extremely healthy-looking fossils are embedded in great quantities in an oolitic ironstone it is difficult to believe that the water could have been so saturated with iron salts that precipitation of the iron could take place on a great scale, unless some altogether special agent intervened. Such precipitation was evidently also a phenomenon strictly limited in time and space. For these and other reasons, which cannot be given in detail here, the present writer has for some time past been driven to the conclusion that oolitic iron ores are in some way due to the action of bacteria. It is only just to say that this conclusion was reached mainly on negative evidence ; that is to say, the absence of any other reasonable explanation. The existence of iron-bacteria may now be taken as established by the work of Vinogradsky, Ellis, and others, and it is satisfactory to find that Professor Cayeux has also come to the same conclusion, apparently on much the same grounds, although he is careful to qualify his statement by the words " in all probability ". Surely there is here a great opening for research. Unfortunately, so far as we are aware, the formation of oolitic iron ores is not now anywhere in progress, and it is not easy to see where the bacteriologist who takes up the subject experimentally will find the material for his cultures.

R. H. RASTALL.

THE SYSTEM Al_2O_3—SiO_2. By N. L. BOWEN and J. W. GREIG. *Journ. Amer. Ceramic Soc.*, vol. vii, 1924, pp. 238–54.

THE work recently carried out at the Carnegie Institution, on the equilibrium relations of mixtures of pure silica and alumina at high temperatures is of the greatest possible interest to students of the physico-chemical side of geology and mineralogy, and of first-class importance, since the authors' conclusions, if finally established, upset a large number of our cherished beliefs as to the behaviour of aluminium silicates under experimental and industrial conditions. Broadly speaking, it is shown that the accepted thermal diagram for melts of silica and alumina is wrong, and it must be remembered that the remodelling of this important binary system involves the reconstruction of several well-known ternary systems.

In the first place the compound $Al_2O_3.SiO_2$ (andalusite, kyanite, or sillimanite) does not occur in laboratory melts or in alumina-silica refractories. The only molecular compound formed has the composition $3Al_2O_3.2SiO_2$. Such crystals have been isolated and analysed, and most careful determinations were made of their crystallographic and physical constants. The resemblance between these crystals and sillimanite is extraordinarily close : crystal-system, cleavage, and optical orientation are identical, and the prism angles differ by only 1°, but the refractive indices α and γ of the new mineral are distinctly lower, being 1·654 and 1·642 instead of 1·677 and 1·657, while the optic axial angle is 45°–50° instead of 25°. It is thus not surprising that this new mineral was for long mistaken for sillimanite.

The most noticeable feature of the new equilibrium diagram is that $3Al_2O_3.2SiO_2$ is the only compound stable at high temperatures; it begins to melt at 1,810°, remaining homogeneous up to that point. The 1 : 1 mixture on the other hand consists of the 3 : 2 compound with cristobalite below the eutectic temperature 1,545°, and of the same compound with liquid above 1,545° (and below 1,810°). Only one eutectic occurs, that between the new compound and cristobalite at 1,545°. There is no eutectic between it and corundum, because it melts incongruently, breaking up into corundum and liquid at 1,810°.

It is obvious that these results are of technical importance, because they show that the 1 : 1 ratio is not the most refractory mixture, as formerly supposed. The 3 : 2 ratio is far superior in this respect, though it is equalled by any mixture with an excess of alumina over such ratio; all such mixtures begin to melt only at 1,810°. The slightest excess of silica over the 3 : 2 ratio will cause melting to begin at 1,545°.

A very brief footnote refers to the interesting fact that since the paper was written this mineral has been discovered in natural rocks in the Island of Mull, and for it the name mullite is proposed. This occurrence has been described in a paper in the *Journal of the Washington Academy of Sciences.*

R. H. R.

AN UNUSUAL TOURMALINE-ALBITE ROCK FROM ENOGGERA, QUEENSLAND. By W. H. BRYAN, M.Sc. Proc. Roy. Soc. Queensland, vol. xxxv, 1923, pp. 48–60, with 1 plate.

THIS peculiar rock, which lies nearly at the contact of the Enoggera granite and the Brisbane schist, consists almost entirely of tourmaline and albite, with only a trace of quartz. Analysis of the albite shows a remarkable excess of both silica and alumina. It is believed that the micaceous parts of the schist have been replaced by tourmaline and the excess of silica removed by leaching. After this, albite introduced from the granite was deposited in spaces left by removal of the original quartz, so that the original structure of the schist is largely preserved, as shown by the plate.

THE SODA-BEARING ROCKS OF KISHENGARH, RAJPUTANA. By A. M. HERON, Rec. Geol. Survey, India. Vol. LVI, Part II. pp. 179–97. 1924.

SOME twenty years ago, attention was called by Sir Thomas Holland and the late Mr. E. W. Vredenburg to a remarkable phenomenon shown by the sodalite of these rocks. There are two varieties of this mineral, one blue, the other colourless when exposed to light. Some crystals of the colourless variety, when freshly broken, were found to be bright pink, the colour fading very rapidly on exposure, but returning after a time when kept in the dark.

This paper contains an account of the field relations and petrography of the rocks containing this peculiar mineral. There are several exposures of the syenites, which are intrusive into the Aravalli series, but apparently older than the Delhi series. Most of the rocks show strong foliation and there are some remarkable pegmatites in which the nepheline and sodalite occur in crystals up to a foot across. The other important minerals are alkali-felspars, a rather peculiar hornblende with high extinction-angle, biotite, cancrinite, and calcite, some of the latter appearing to be primary. Several analyses are given.

No explanation is offered of the unusual behaviour of the sodalite.

THE COLLOIDAL CHEMISTRY OF MINERALS AND ORE DEPOSITS. By W. LINDGREN. Reprint from *The Theory and Application of Colloidal Behaviour.* pp. 445–65. New York: McGraw-Hill Book Co., Inc. 1924.

THE RÔLE OF COLLOIDAL SOLUTIONS IN THE FORMATION OF MINERAL DEPOSITS. By H. C. BOYDELL. Bull. Inst. Min. Met., No. 243. pp. 108. 1924.

APPLICATION OF COLLOID CHEMISTRY TO MINERALOGY AND PETROLOGY. By A. SCOTT. Fourth Report on Colloid Chemistry. Brit. Ass. Adv. Sci. pp. 204–43. 1922.

DIE KOLLOIDCHEMIE ALS HILFSWISSENSCHAFT DER MINERALOGIE UND LAGERSTÄTTENLEHRE. By F. BERNAUER. Berlin: Borntraeger, 1924.

THE four memoirs whose titles appear at the head of this review give a comprehensive account of the present state of our knowledge of this complicated but important subject. Dr. Boydell discusses very fully the possible applications of colloid chemistry with special application to ore-deposits and their attendant phenomena, while Dr. Scott's report is of special value from the completeness of its bibliographical apparatus. It is impossible here to deal with the vast number of problems raised in these publications, which cover the whole scope of the subject as at present known. It must suffice to point out the wide field for investigation here opened up for geologists and mineralogists both from the theoretical and practical points of view. The principles of colloid chemistry in the modern acceptation of the term undoubtedly offer an explanation of a great number of peculiarities of rocks and minerals that offer puzzling problems when regarded from the ordinary physico-chemical standpoint, since colloidal systems and especially those where the phenomena of adsorption are manifested are not amenable to treatment by the ordinary methods founded on the phase-rule.

There is no possible doubt that many rocks and minerals show conspicuously the types of structure that are characteristic of deposition from colloidal dispersion. For these types of structure, including the oolitic, pisolitic, mamillary, botryoidal, reniform, and stalactitic forms, and many varieties of concentric, radial, banded, and structures, spherulitic the general term *colloform* has been suggested. This term is certainly useful, if it is distinctly understood not to imply a dogmatic statement as to the exact mode of origin of the particular substance concerned. Some minerals in their mature form may be regarded as actually constituting gels, such as opal, glauconite, asbolane, and garnierite, but the vast majority of the colloform minerals are now undoubtedly crystalline, though originally deposited from colloidal suspension. This category includes also a good many finely divided substances dispersed in other solids, such as gold and cinnabar. It is an important point that mineral precipitates due to organic agency, including calcium carbonate and iron oxides and hydroxides, pass through the colloid state, as probably do the finely divided sulphides of the marine deposits. Phosphates also are specially liable to this kind of deposition, though here bacterial agency is not established.

It is now believed that silica in solutions is always in the form of a colloidal dispersion and not as a true molecular solute, this substance having a very strong tendency to gel formation, so that there is a continuous series from silica in "solution" to such hard minerals as opal and agate, the water-content showing continuity, with no breaks on the dehydration curve. In this respect the water-content of the zeolites offers a problem difficult of solution.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN: VOL. VIII. IRON ORES: HAEMATITES OF WEST CUMBERLAND, LANCASHIRE AND THE LAKE DISTRICT. By BERNARD SMITH, M.A., SC.D. Second edition. pp. 233, with 5 plates and 31 figures. 1924. Price 5*s*. net.

THE first edition of this admirable memoir, published in 1919, contained 182 pages, 4 plates, and 29 figures, and cost nine shillings. The present edition with 51 more pages, and an extra plate, the whole printed on much better paper, is published at five shillings. At this price it is a remarkably cheap book, and the Survey is to be congratulated on its appearance. The work of revision and bringing up to date has been greatly facilitated by the fact that the author has now for some years resided permanently at Whitehaven, in charge of a branch office of the Geological Survey. He has thus been in close touch with all the recent developments in this field. It is impossible, without entering into too much detail, to notice all or even a part of the many additions to the work, which is now more than ever valuable as a compendium of the available information on this area. We should like to mention the greatly improved appearance of the illustrations on the new paper. We could wish, however, that the review copy had been sent out by the publishers packed flat instead of doubled up. Such treatment often seriously damages books of this size, and leaves an unpleasant permanent crease on the cover and most of the pages.

THE GEOLOGY OF THE COUNTRY AROUND DARTFORD. Explanation of one-inch Sheet 271 England. By H. DEWEY, C. E. N. BROMEHEAD, C. P. CHATWIN, and H. G. DINES. Mem. Geol. Survey. pp. vi + 136, 2 plates, 1 text-figure. 1924. Price 3*s*.

THE GEOLOGY OF THE COUNTRY AROUND HERTFORD. Explanation of one-inch Sheet 239 England. By R. L. SHERLOCK and R. W. POCOCK. Mem. Geol. Survey. pp. vii+66, 2 text-figures. 1924. Price 1*s*. 6*d*.

THE appearance of the Survey Memoirs is much enhanced by the adoption of a cover of more pleasing hue and greatly improved design.

Both the above works deal mainly with the Chalk, the Eocene, and the Pleistocene. The Hertford district is largely drift-covered, and the solid formations not well exposed. The Pleistocene and River Deposits are treated in detail ; and a contour map of the infra-Tertiary surface adds to the interest of the Memoir.

In describing the classical Dartford area, the opportunity has been taken of giving a succinct account of the present methods of zoning the English Chalk. The described variations of certain genera with horizon are mentioned, with references ; a lucid and adequately illustrated summary of Dr. Rowe's classic "Analysis of the Genus *Micraster*" forms an excellent introduction to the subject. The detailed description of the Eocene briefly notes the results of recent attempts at zoning and correlation with French and Belgian deposits. The river gravels and associated deposits, their fauna and flint implements, are dealt with in the last chapters of what should prove a very popular Memoir. A. G. B.

REPORTS AND PROCEEDINGS.

LIVERPOOL GEOLOGICAL SOCIETY.

11*th November*, 1924.

The following paper was read : "Some Evidences of Early Man within and near the Northern Portion of the Vale of Clwyd," by F. Gilbert Smith, Prestatyn.

The object of the paper was to furnish a preliminary account of evidences of early man found in the district during the last year or two. Interest in the subject was first aroused by the discovery near the Prestatyn railway station, early in 1923, of a human skeleton, described by Sir Arthur Keith as "The Prestatyn Lady".

This was found at the bottom of a four-feet bed of peat overlying boulder clay, with a thin layer of blue estuarine clay intervening. Since then a large collection of human artefacts has been obtained, mostly from what appears to be undisturbed boulder clay, at a depth of about six feet from the surface. The implements are of primitive type, and are fashioned of flint, chert, and other stones. Among them, circular and leaf-shaped scrapers are very common, but a classification has not yet been attempted, as they are probably representative of different periods. In the opinion of the author there are points of resemblance between them and those of Penmaenmawr discovered by Mr. S. Hazzledine Warren. The investigations are being actively continued, and it is hoped that it will be possible to give more definite results at an early date.

CORRESPONDENCE.

THE GEOLOGY OF YORKSHIRE.

Sir,—We regret to find that on p. 31 of "The Geology of Yorkshire", a communication that Dr. Elles was good enough to make to us in 1917 of her views on the zoning of the Older Palaeozoic rocks of N.W. Yorkshire, was summarized more succinctly than would perhaps accurately convey her opinions. Dr. Elles assures us that her views support rather than detract from the strength of the classification which Professor Marr has put forward. A further small correction is necessary in the table where the line dividing the Wenlock from the Ludlow should be drawn between the zones of *Cyrtograptus lundgreni* and *Monograptus nilssoni*, and therefore between the Moughton Flagstones and the Coldwell Beds of the table. It should also be noted that Dr. Elles is unable to recognize any Lower Llandovery in this area.

P. F. Kendall.
H. E. Wroot.